

LECTURE 7: INTRODUCTION TO AUGMENTED REALITY

COMP 4010 – Virtual Reality

Semester 5 – 2017

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South Australia

Augmented Reality



1977 – Star Wars

Augmented Reality Definition

- Defining Characteristics [Azuma 97]
 - Combines Real and Virtual Images
 - Both can be seen at the same time
 - Interactive in real-time
 - The virtual content can be interacted with
 - Registered in 3D
 - Virtual objects appear fixed in space

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

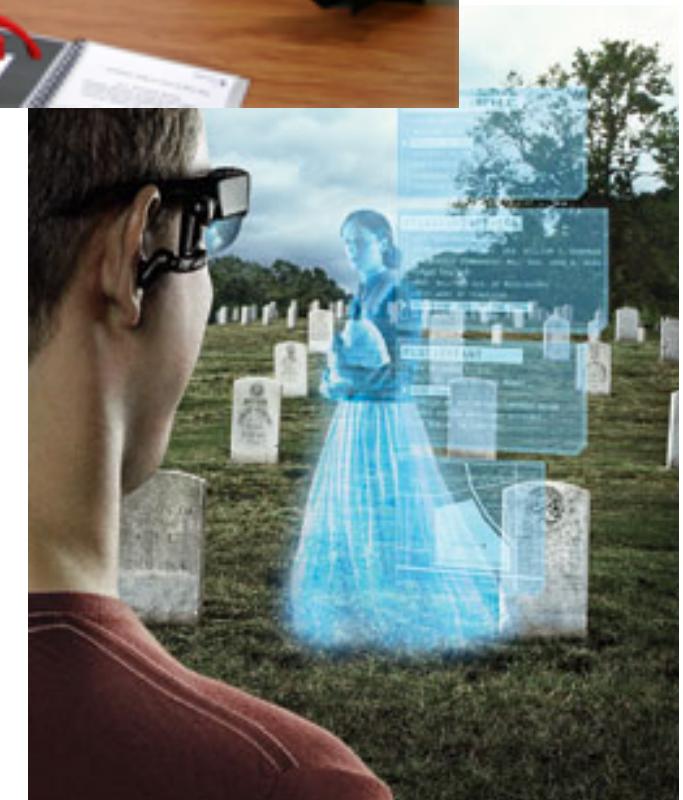
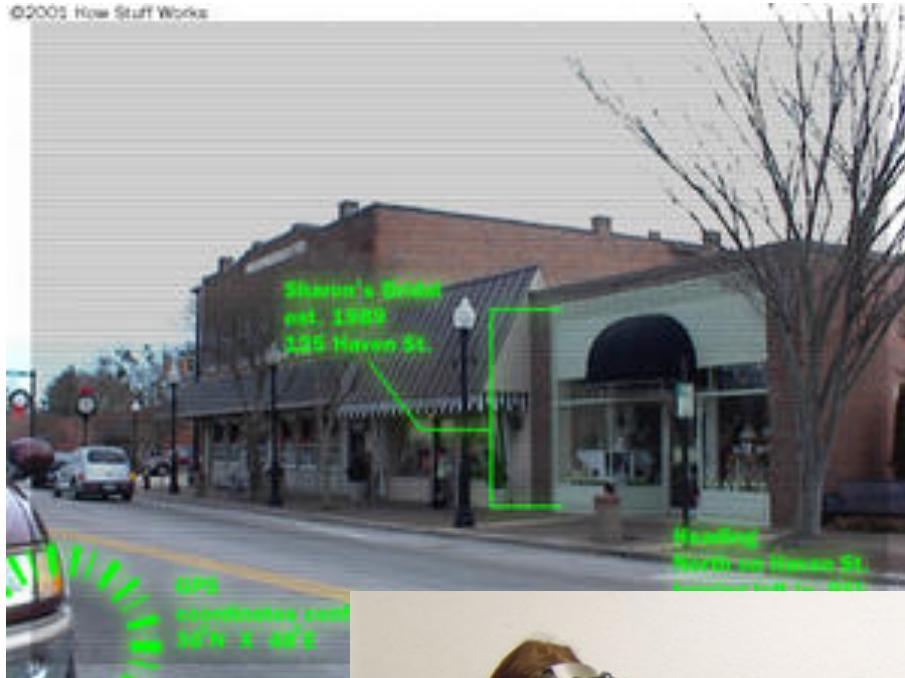
CNN 2008 Election Demo



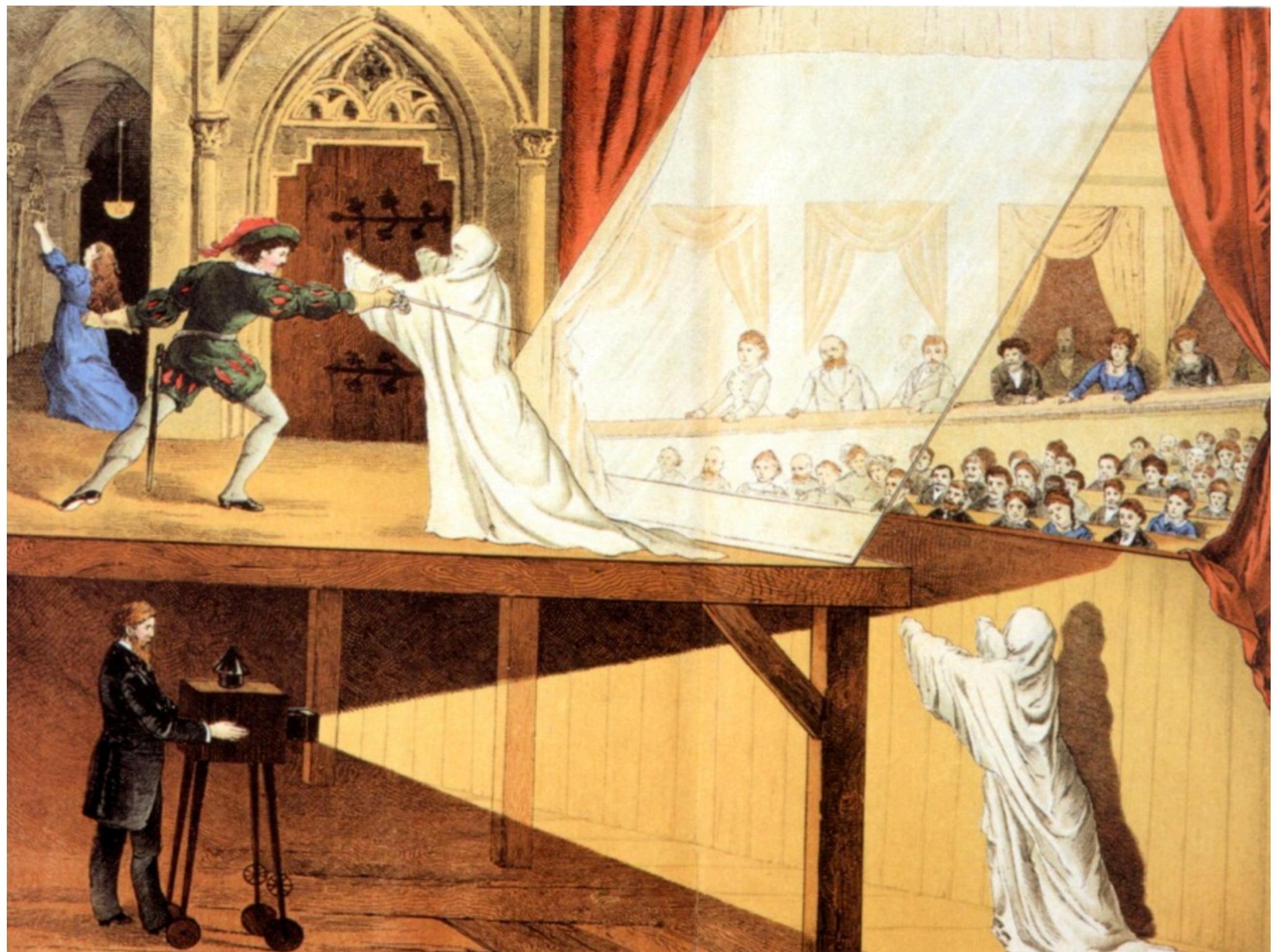
https://www.youtube.com/watch?v=v7fQ_EsMJMs

Augmented Reality Examples

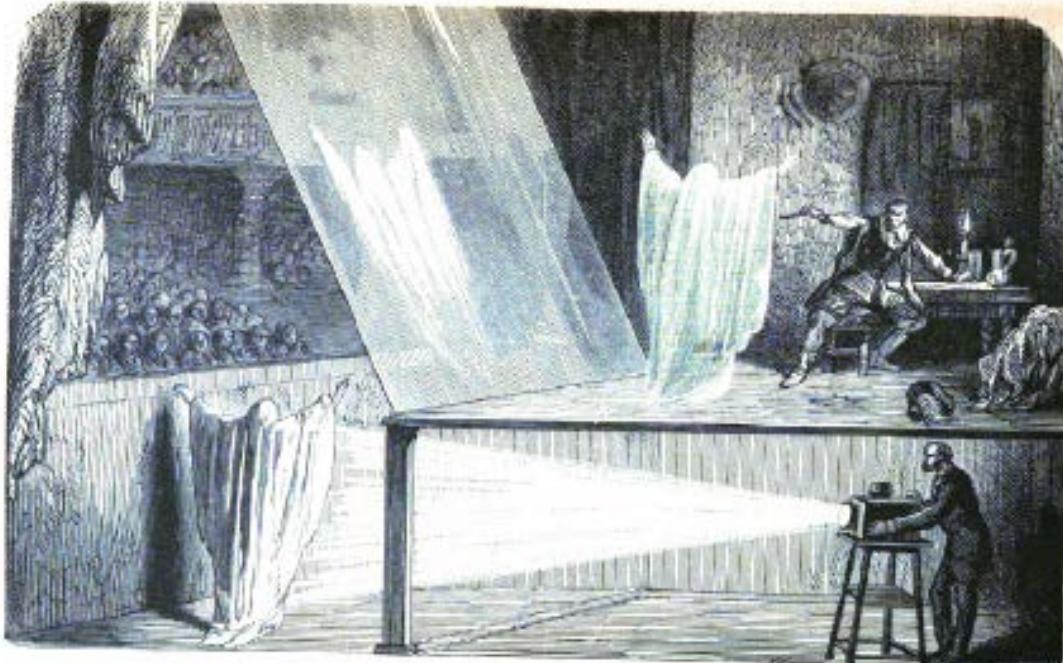
©2005 How Stuff Works



HISTORY OF AR



Pepper's Ghost (1862)

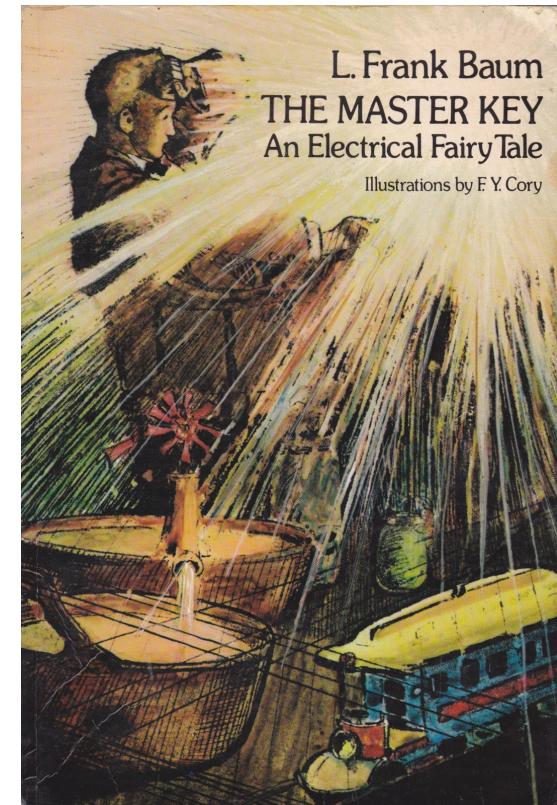


- Dates back to Giambattista della Porta (1584)

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

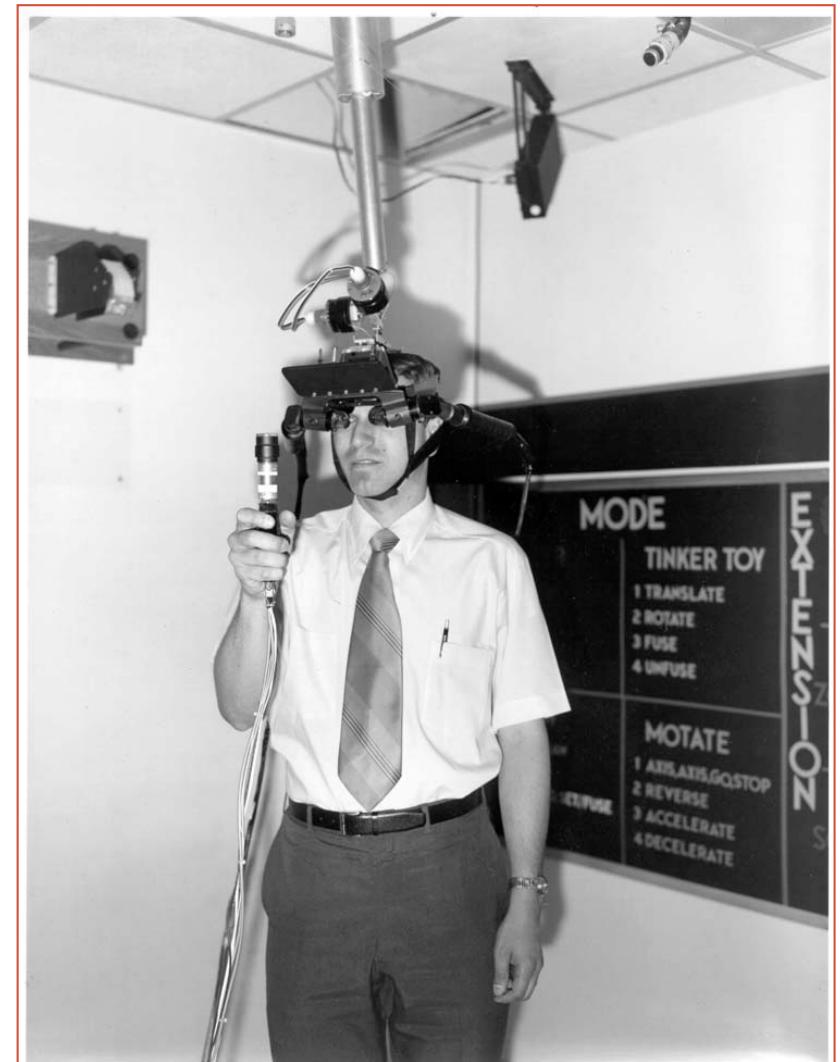
First HMD



- Philco Headsight (1961) – Remote Camera Viewing

Sutherland HMD

- 1968: Sutherland / Sproull's first HMD system
 - see-through

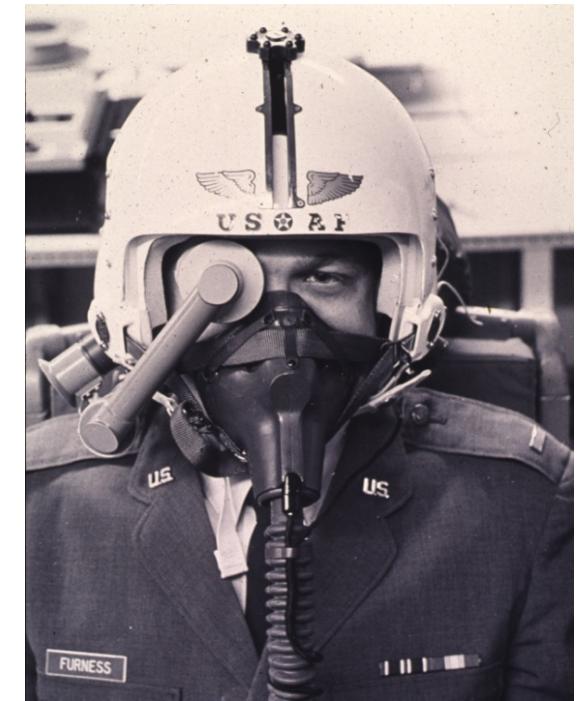
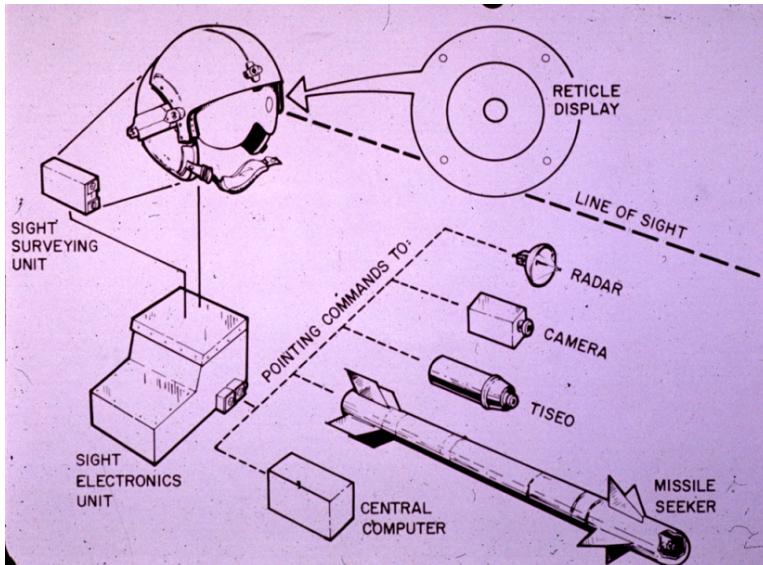


Sutherland Display



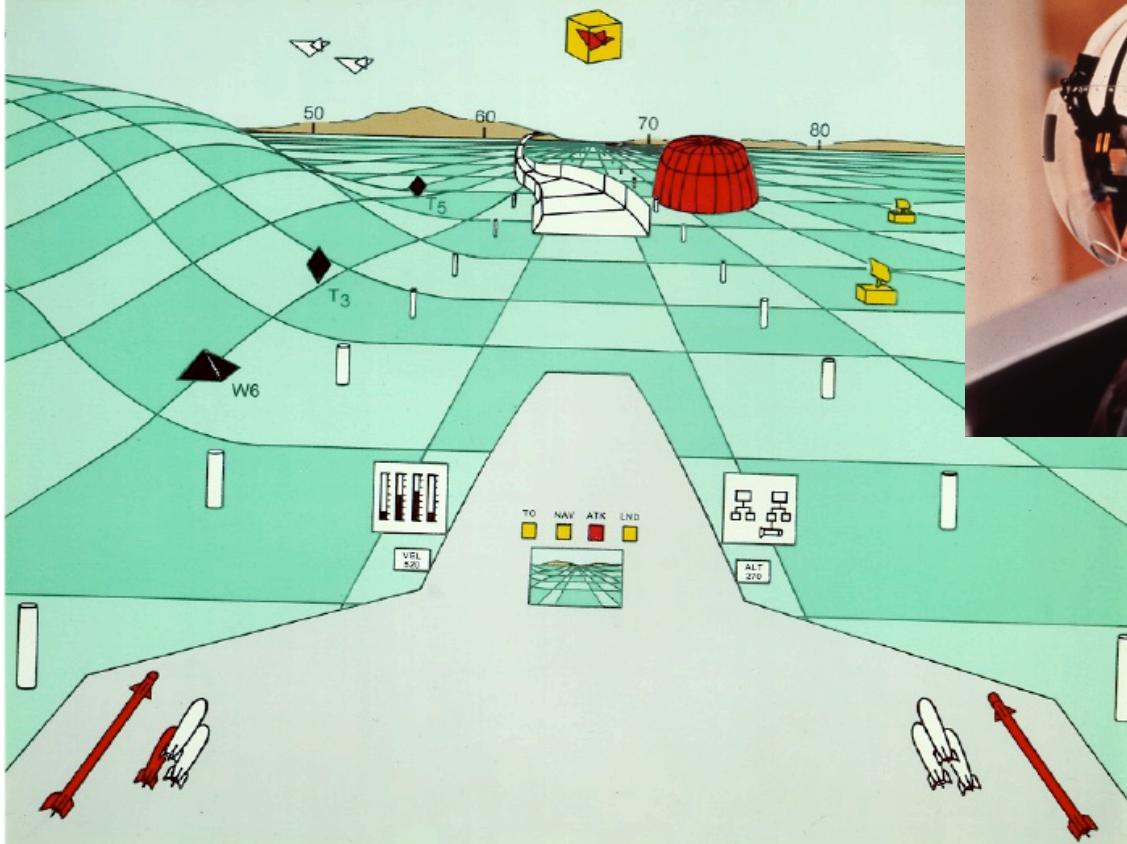
<https://www.youtube.com/watch?v=eeVKAIYqKtg>

US Airforce HMDs



1960 - 70's: US Air Force HMDs (T. Furness III)

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)



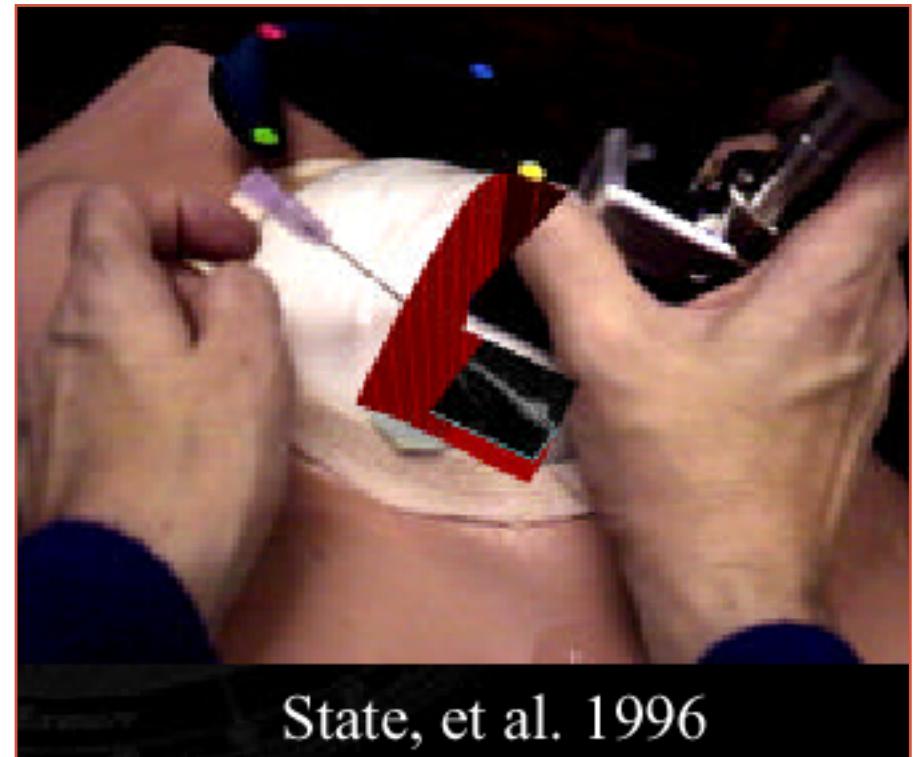
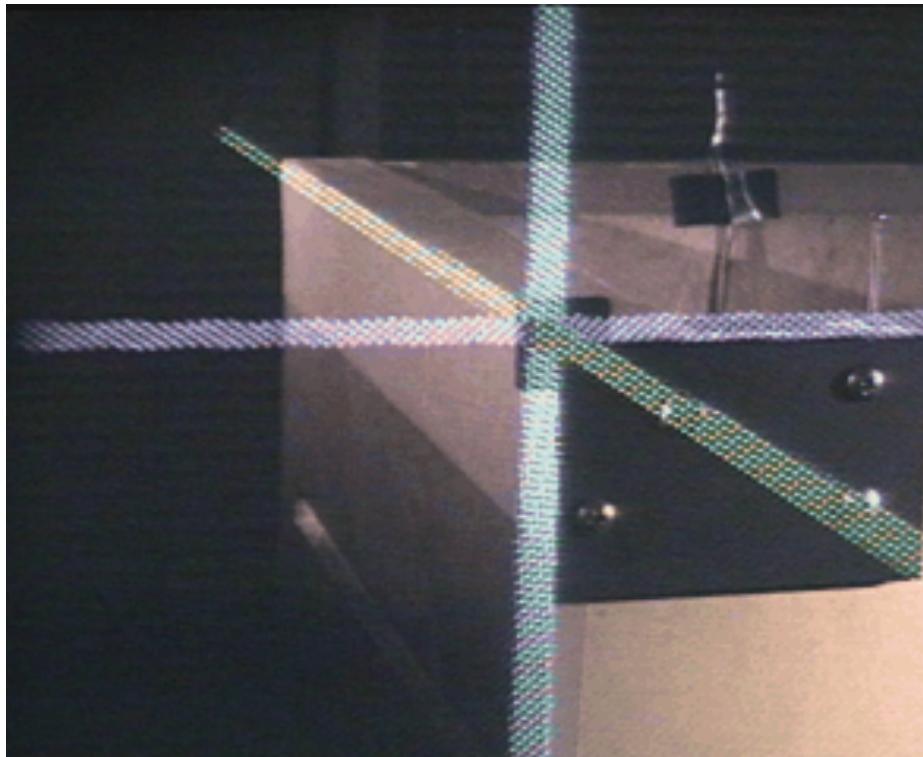
- <https://www.youtube.com/watch?v=Ay6g66FbkmQ>

First Industrial Use



- Early 1990's: Boeing coined the term "AR." Wire harness assembly application begun (T. Caudell, D. Mizell).

Academic Research Beginning



- 1994: Motion stabilized display [Azuma]
- 1995: Fiducial tracking in video [Bajura / Neumann]
- 1996: UNC hybrid magnetic-vision tracker

Development of the Field

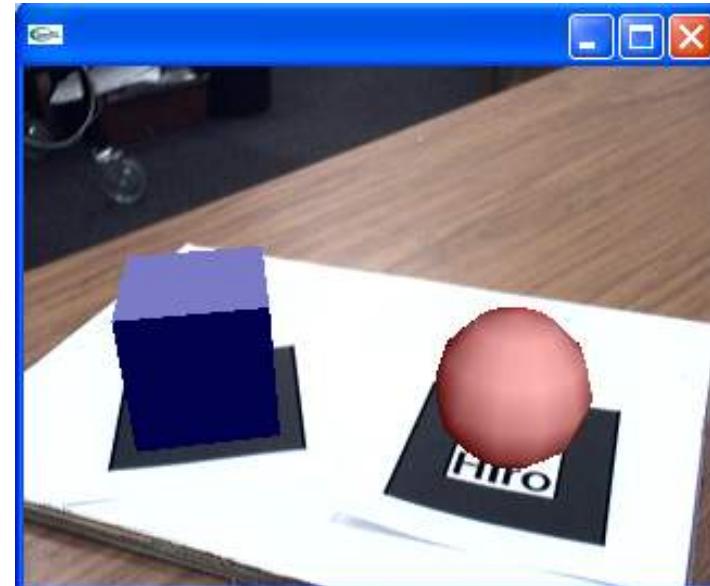
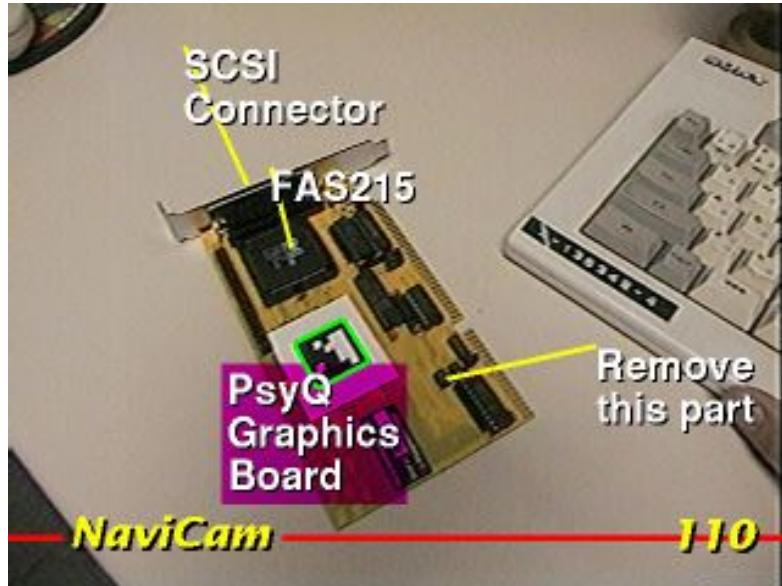


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- 1996: MIT Wearable Computing efforts
- 1998: Dedicated conferences begin (ISMAR)
- Late 90's: Collaboration, outdoor, interaction
- Late 90's: Augmented sports broadcasts

Development of Tools



- 1996 CyberCode (Rekimoto)
 - First matrix code tracking
- 1999 ARToolKit (Kato & Billinghurst)
 - Open source tracking library

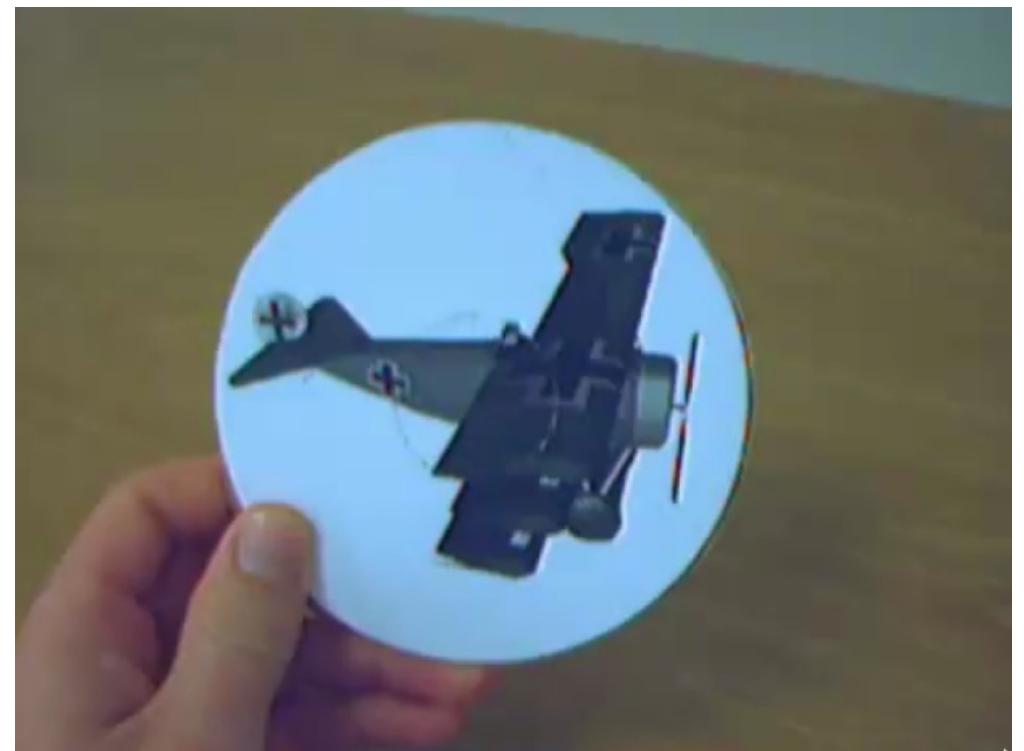
Tracking Demos

<https://www.youtube.com/watch?v=cNFwEMkLK4A>



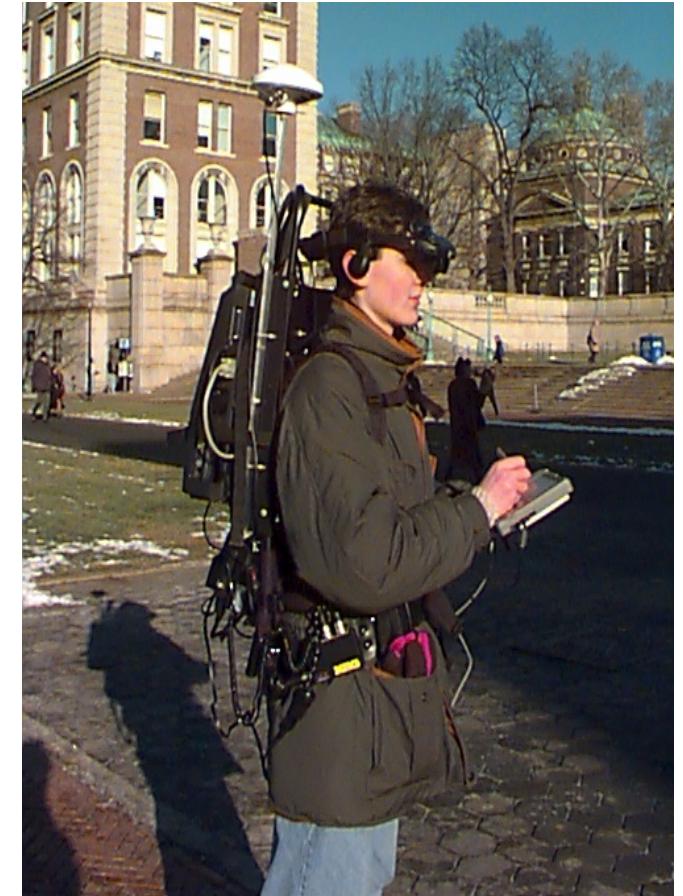
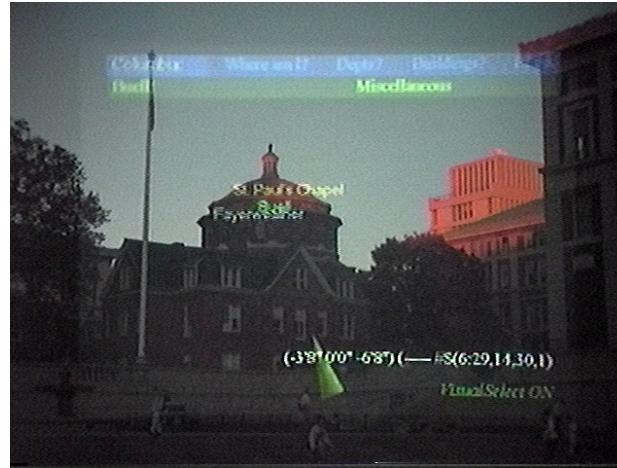
Cybercode

ARToolKit



<https://www.youtube.com/watch?v=TqGAqAFIGg0>

Mobile/Wearable Systems



- 1995 Navicam (Rekimoto)
 - Handheld AR
- 1997 Touring Machine (Feiner)
 - Backpack AR
 - GPS, see-through display

History Summary

- 1960's – 80's: Early Experimentation
- 1980's – 90's: Basic Research
 - Tracking, displays
- 1995 – 2005: Tools/Applications
 - Interaction, usability, theory
- 2005 - : Commercial Applications
 - Games, Medical, Industry

2007 - AR Reaches Mainstream

- MIT Technology Review

- March 2007
- list of the 10 most exciting technologies

- Economist

- Dec 6th 2007
- Reality, only better



2009 - AR in Magazines

- Esquire Magazine
 - Dec 2009 issue
 - 12 pages AR content
- Many Others
 - Wired
 - Colors
 - Red Bull
 - Etc



Esquire Demo



<https://www.youtube.com/watch?v=LGwHQwgBzSI&t=1s>

Google Searches for AR

"augmented reality" — 1.00 "virtual reality" — 5.20



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://www.youtube.com/watch?v=vJO_AZkCL9U

2005 - Mobile Phone AR

- **Mobile Phones**
 - camera
 - processor
 - display
- **AR on Mobile Phones**
 - Simple graphics
 - Optimized computer vision
 - Collaborative Interaction

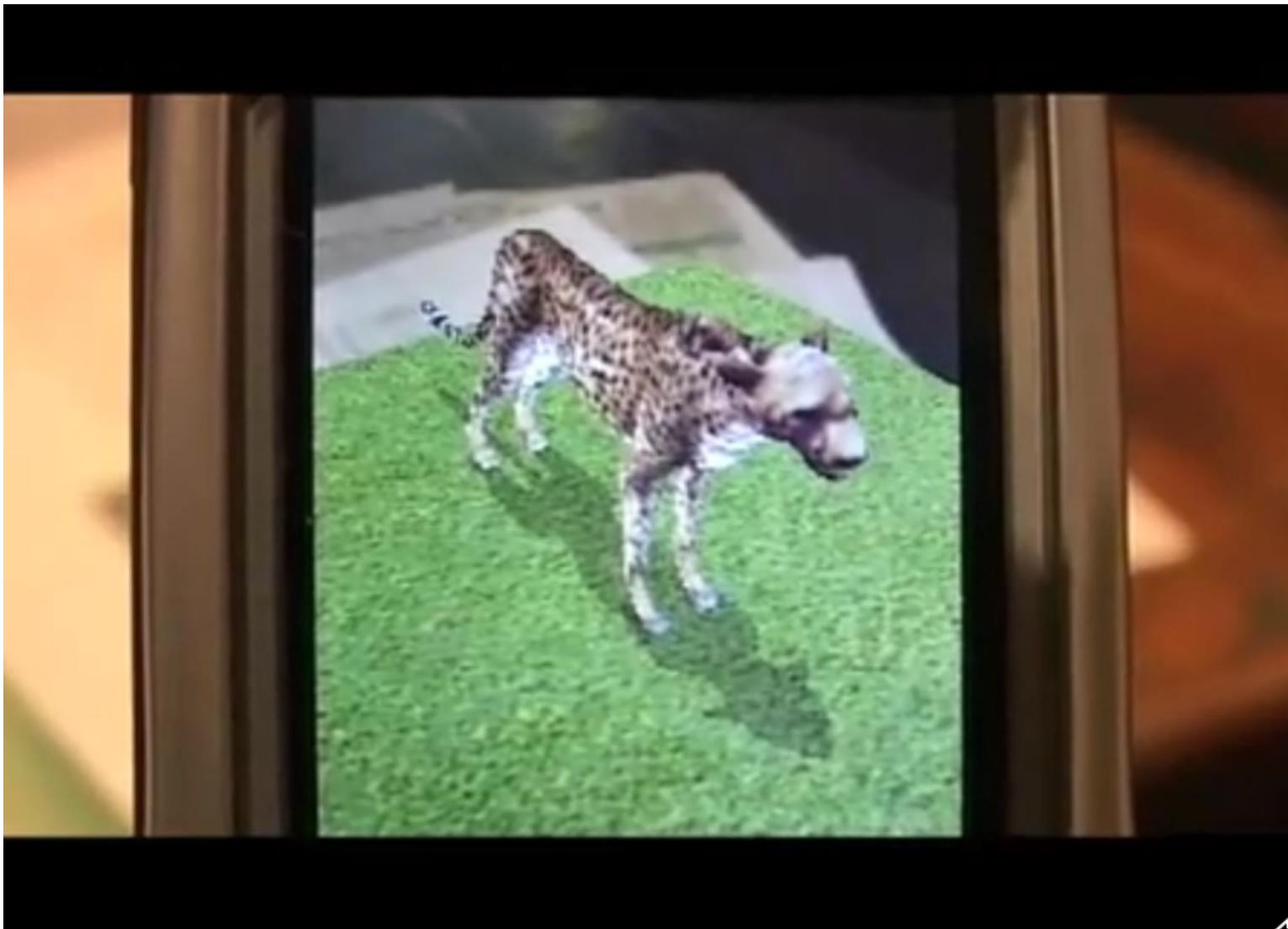


AR Advertising (HIT Lab NZ 2007)



- 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://www.youtube.com/watch?v=edTjuXcce_c

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 (2007)



- https://www.youtube.com/watch?v=b64_16K2e08

Google Glass (2011 -)



Google Glass Demo



<https://www.youtube.com/watch?v=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://www.youtube.com/watch?v=2c9eiVyO6gM>

Smart Glasses Available



Google Glass



Epson BT200



Vuzix m100



Optinvent ORA-X



Recon Jet



Laster SeeThru



Meta Pro



Atheer One



Lumus DK40



ODG Consumer

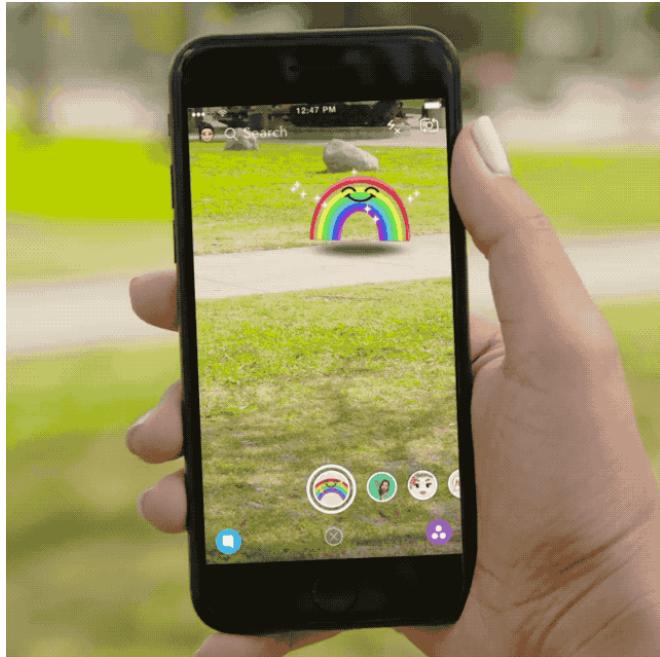


Sony SmartEyeGlasses

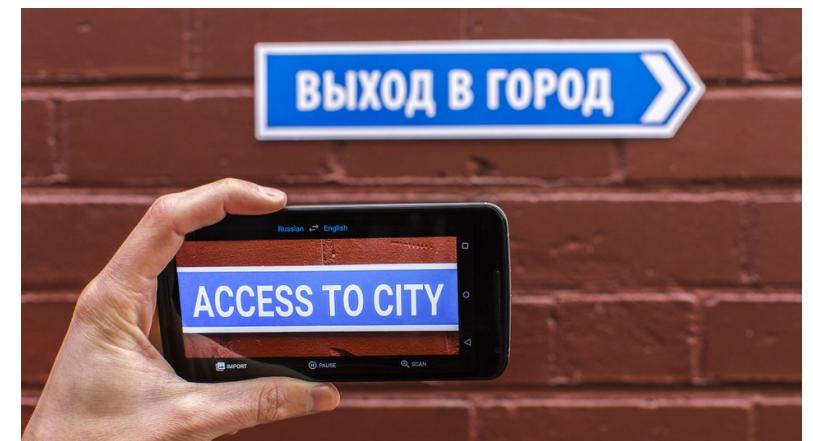


Microsoft Hololens

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 (Intertial)
- Features
 - Plane detection, lighting detection, hardware optimisation
- Links
 - <https://developer.apple.com/arkit/> <https://developers.google.com/ar/>

ARKit Demos



<https://www.youtube.com/watch?v=6xDyVBsBtX8>

Strong vs. Weak AR

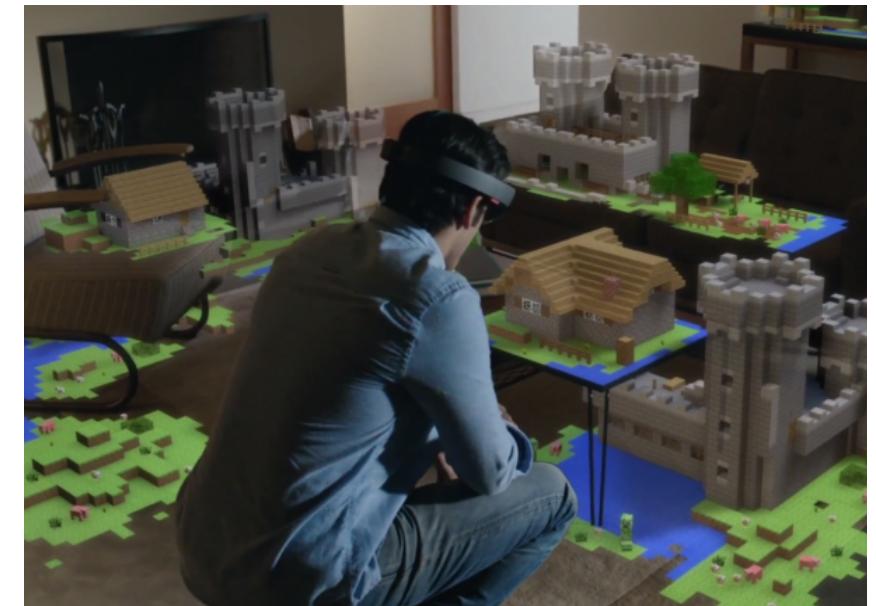
- **Weak AR**

- 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



Augmented Reality Today

- **Key Technologies Available**
 - Robust tracking (Computer Vision, GPS/sensors)
 - Display (Handheld, HMDs)
 - Input Devices (Kinect, etc)
 - Developer tools (Vuforia, ARToolKit)
- **Commercial Business Growing**
 - Gaming, GPS/Mobile, Online Advertisement
 - >\$600 Million USD in 2016

AR Business Today

- Marketing
 - Web-based, mobile
- Mobile AR
 - Geo-located information and service
 - Driving demand for high end phones
- Gaming
 - Mobile, Physical input (Kinect, PS Move)
- Upcoming areas
 - Manufacturing, Medical, Military



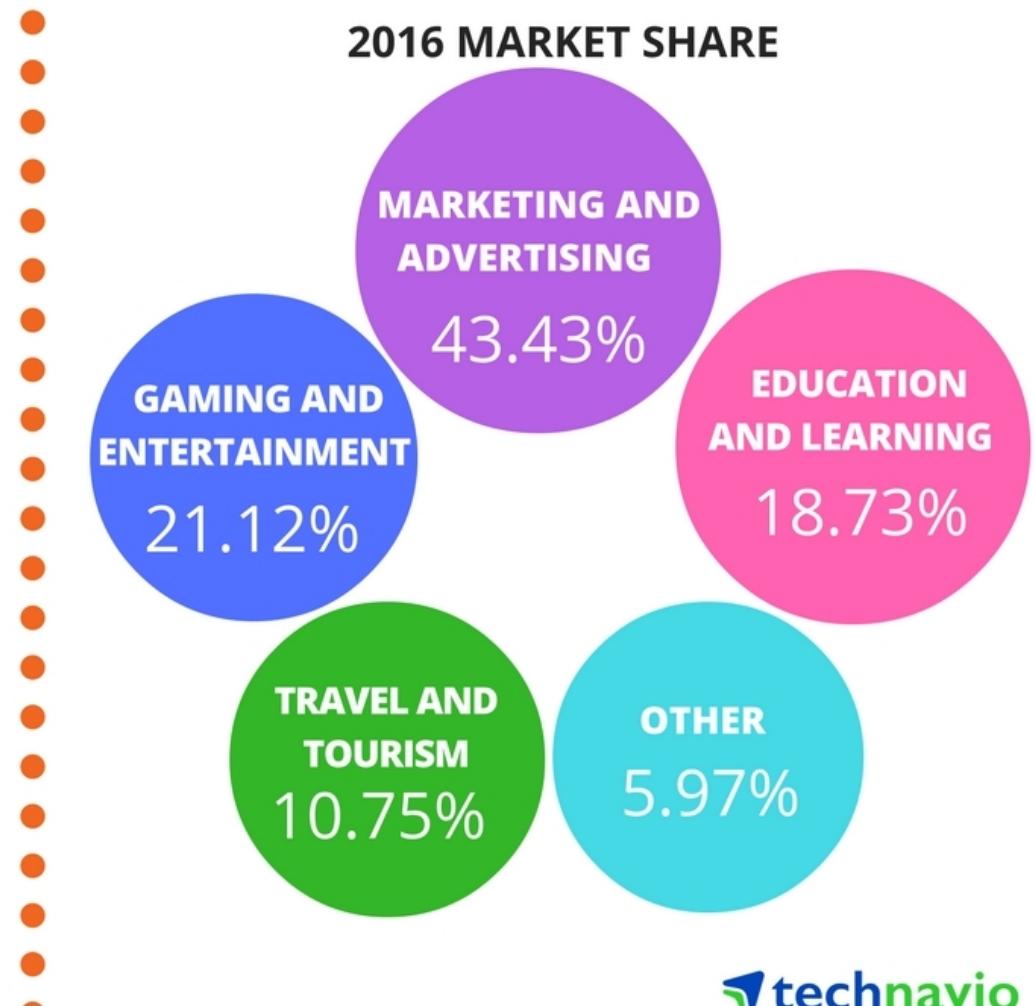
AR Business Today



- Around \$600 Million USD in 2014 (>\$2B 2016)
- 70-80+% Games and Marketing

GLOBAL MOBILE AUGMENTED REALITY (AR) MARKET BY APPLICATION

APPLICATION	REVENUE 2016
MARKETING AND ADVERTISING	\$1.09 billion
GAMING AND ENTERTAINMENT	\$0.53 billion
EDUCATION AND LEARNING	\$0.47 billion



THE VR FUND Q2 2017 AR INDUSTRY LANDSCAPE

APPLICATIONS

GAMES/ENTERTAINMENT



CONSUMER



ENTERPRISE



HEALTHCARE



EDUCATION



TOOL/PLATFORM

DISTRIBUTION



SDK



3D TOOLS (ENGINES/AUDIO)



3D REALITY CAPTURE



INFRASTRUCTURE

DEVICES (MR HMD/AR HMD/HANDHELD MR)



COMPONENTS (DISPLAY/3D CAMERAS/INPUT/COMPUTER VISION)

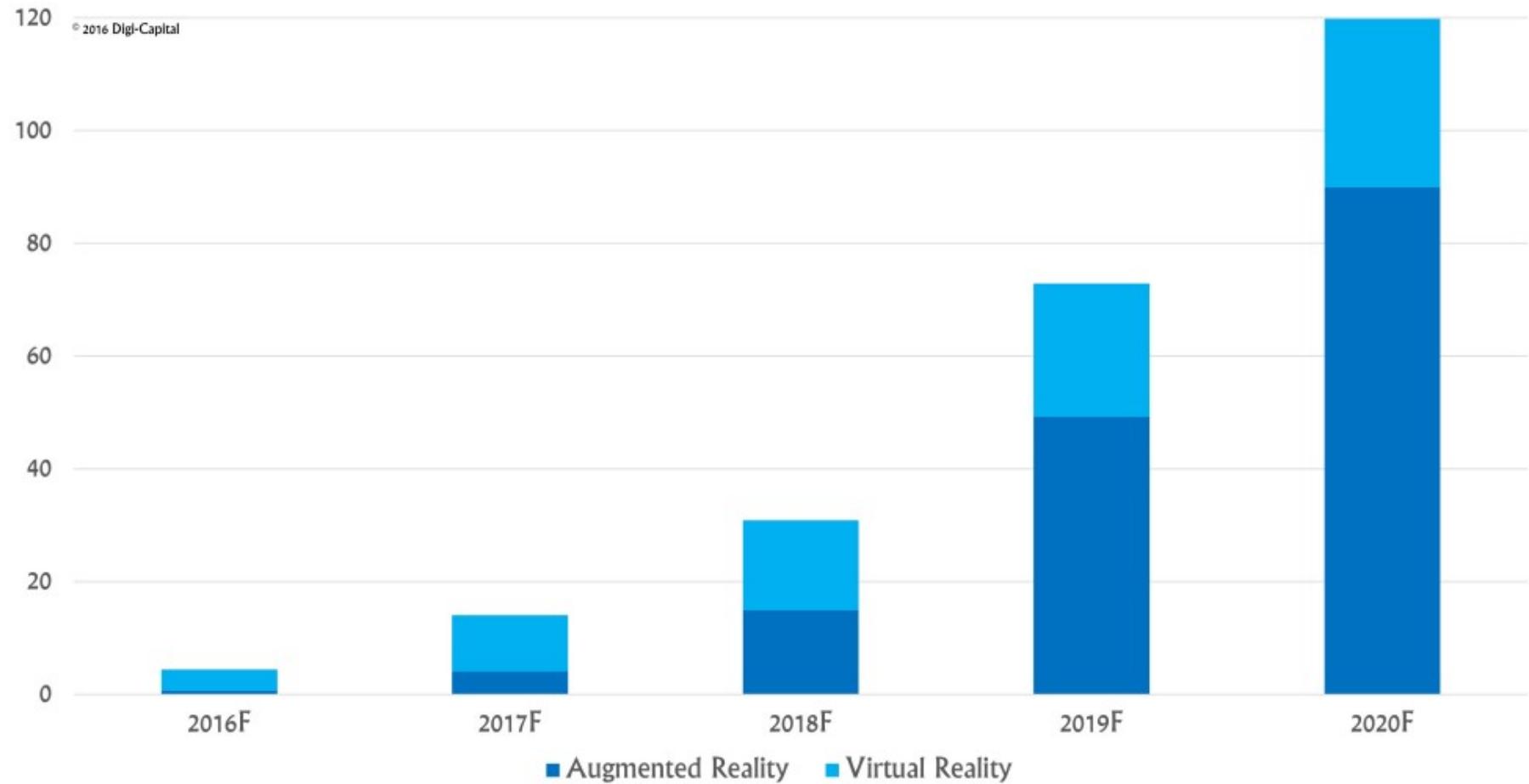


Crossing the Chasm - 5-10 years



Market Projections

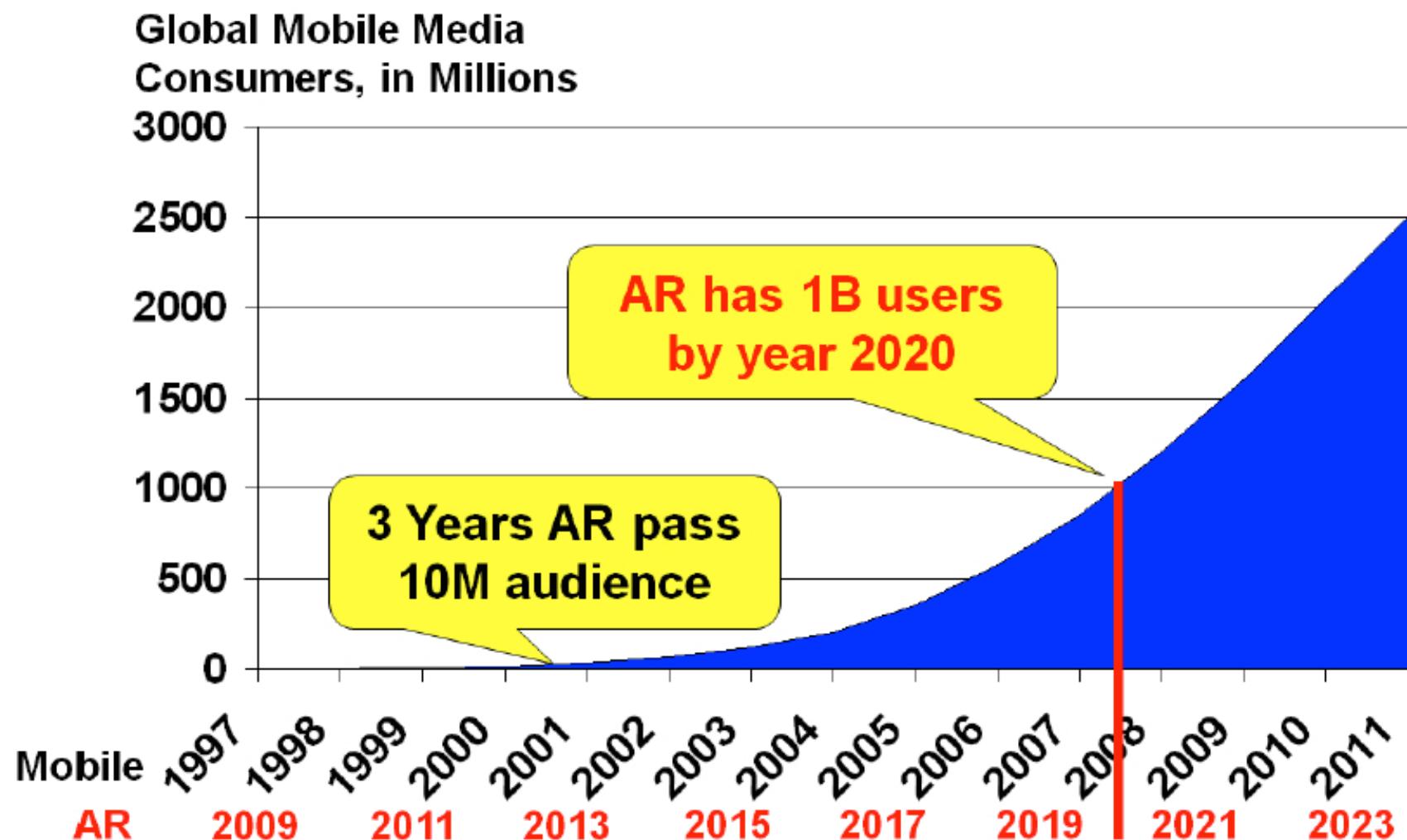
Digi-Capital™ Augmented/Virtual Reality Revenue Forecast (\$B)



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cf. 2014 computer game market = \$84 Billion USD

Forecast Number of Users

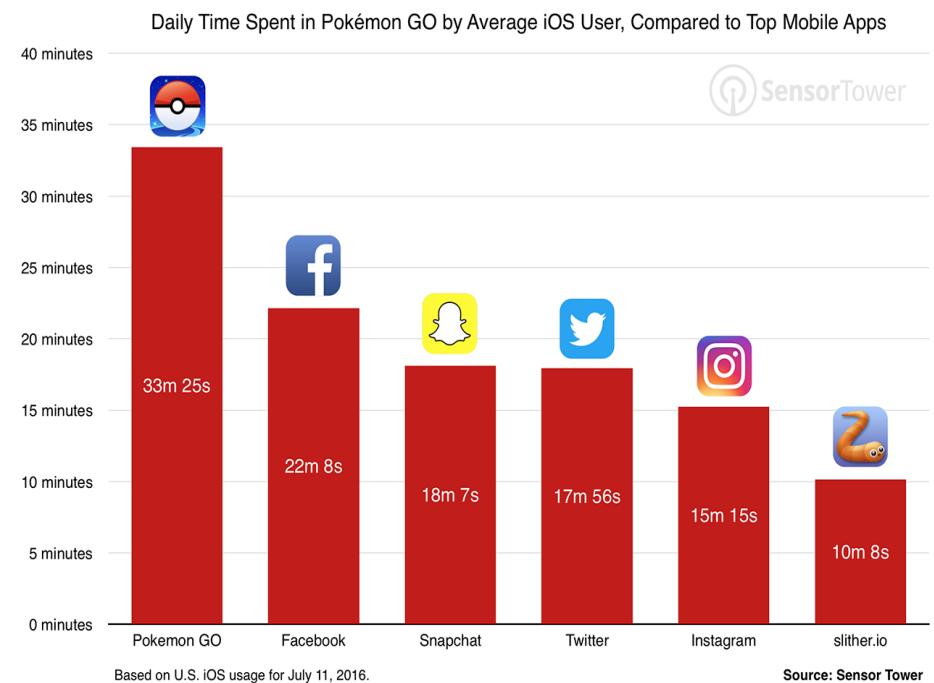
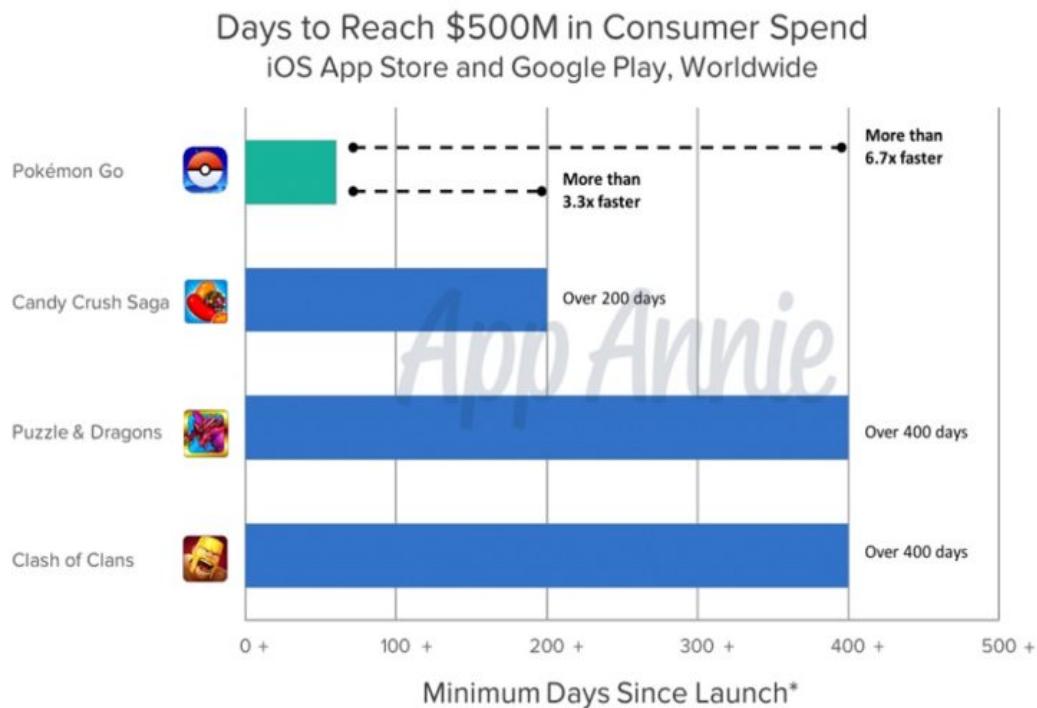


Pokemon GO



Killer Combo: brand + social + mobile + geo-location + AR

Pokemon GO Effect



- Fastest App to reach \$500 million in Revenue
 - Only 63 days after launch, > \$1 Billion in 6 months
 - Over 500 million downloads, > 25 million DAU
 - Nintendo stock price up by 50% (gain of \$9 Billion USD)

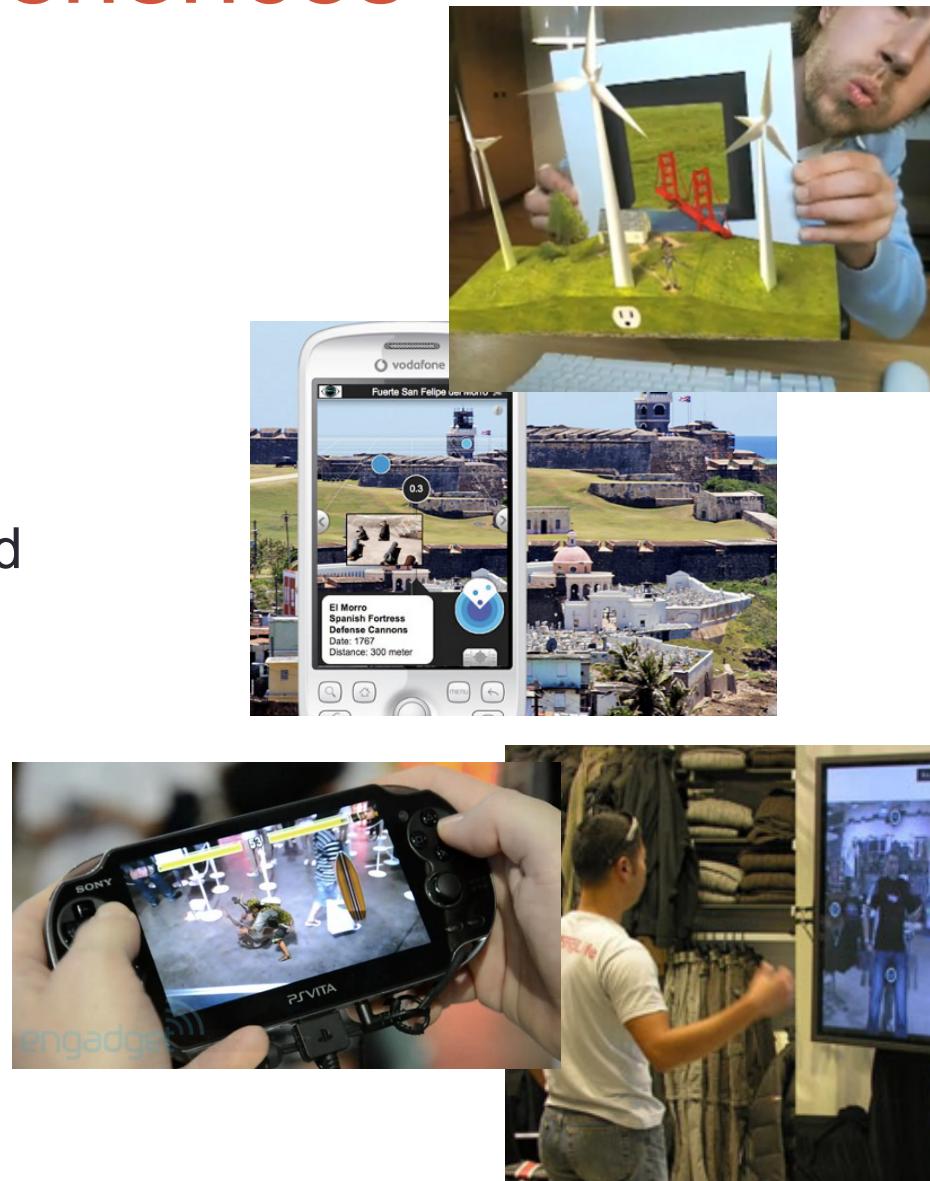
Summary

- Augmented Reality has a long history going back to the 1960's
- Interest in AR has exploded over the last few years and is being commercialized quickly
- AR is growing in a number of areas
 - Mobile AR
 - Web based AR
 - Marketing experiences

SAMPLE AR APPLICATIONS

Typical AR Experiences

- Web based AR
 - Flash, HTML 5 based AR
 - Marketing, education
- Outdoor Mobile AR
 - GPS, compass tracking
 - Viewing Points of Interest in real world
 - Eg: Juniaio, Layar, Wikitude
- Handheld AR
 - Vision based tracking
 - Marketing, gaming
- Location Based Experiences
 - HMD, fixed screens
 - Museums, point of sale, advertising



AR Books – Markerless Tracking



Example: Haunted Book/AR Book



- Camera hidden in lamp object
- AR content seamlessly integrated into real book
- Natural page turning/manipulation interaction

Scherrer, C., Pilet, J., Fua, P., & Lepetit, V. (2008, September). The haunted book. In *Proceedings of the 7th IEEE/ACM international Symposium on Mixed and Augmented Reality* (pp. 163-164). IEEE Computer Society.

AR Book Demo



<https://www.youtube.com/watch?v=XbsfamN78Tc>

Gaming: Rock-em Sock-em



- Shared AR Demo
- Markerless tracking

Rockem Sockem Demo



<https://www.youtube.com/watch?v=hXtq1qBMLIw>

Sales and Marketing

- Connect with brands and branded objects
- Location Based Experiences
 - Lynx Angels
- Web based
 - Rayban glasses
- Mobile
 - Ford Ka campaign
- Print based
 - Red Bull Magazine



Pepsi AR Experience (2014)



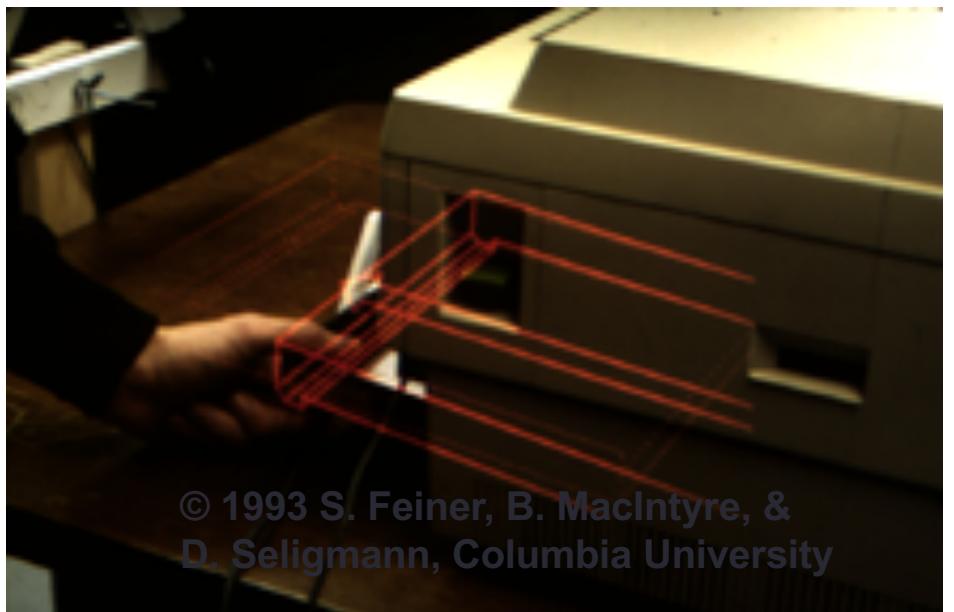
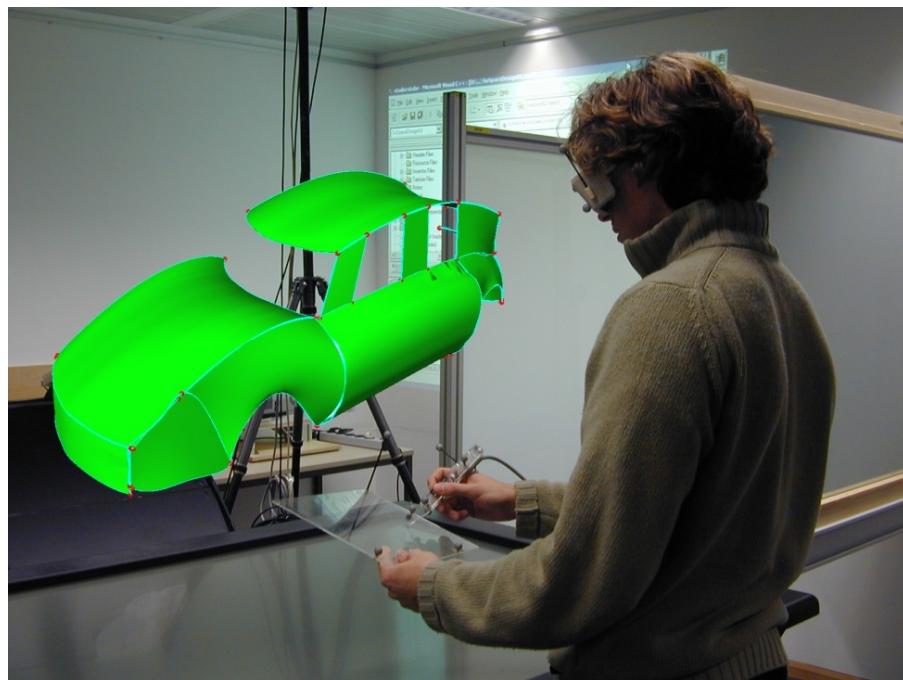
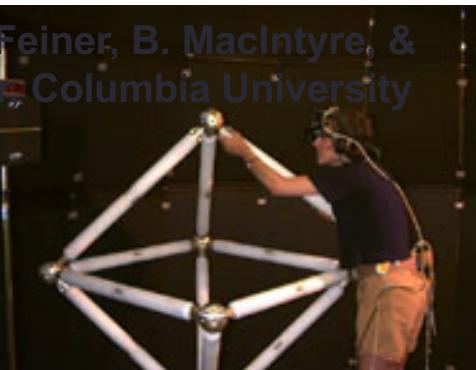
- Video see-through AR in bus shelter
- Bus shelter appears under attack

Pepsi Demo



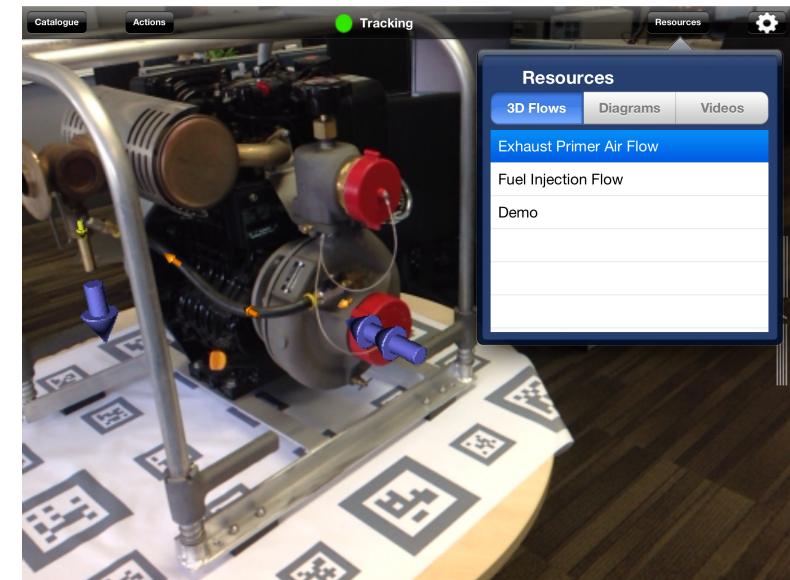
<https://www.youtube.com/watch?v=Go9rf9GmYpM&t=7s>

Assembly and Maintenance



Maintenance Systems

- Ngrain
 - <http://www.ngrain.com/>
 - Training authoring tool
 - Model based AR tracking
- ScopeAR
 - <http://www.scopear.com/>
 - Remote assistance
 - Image based tracking



Ngrain Example



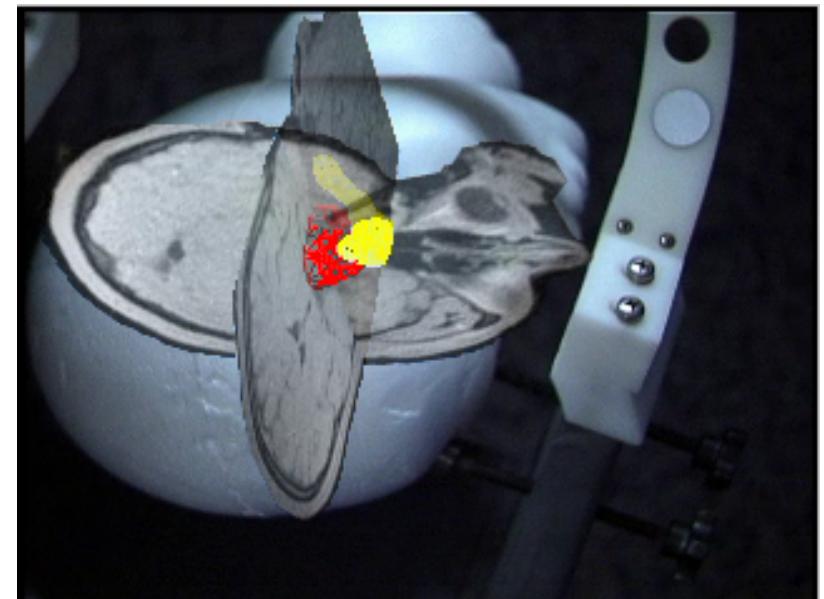
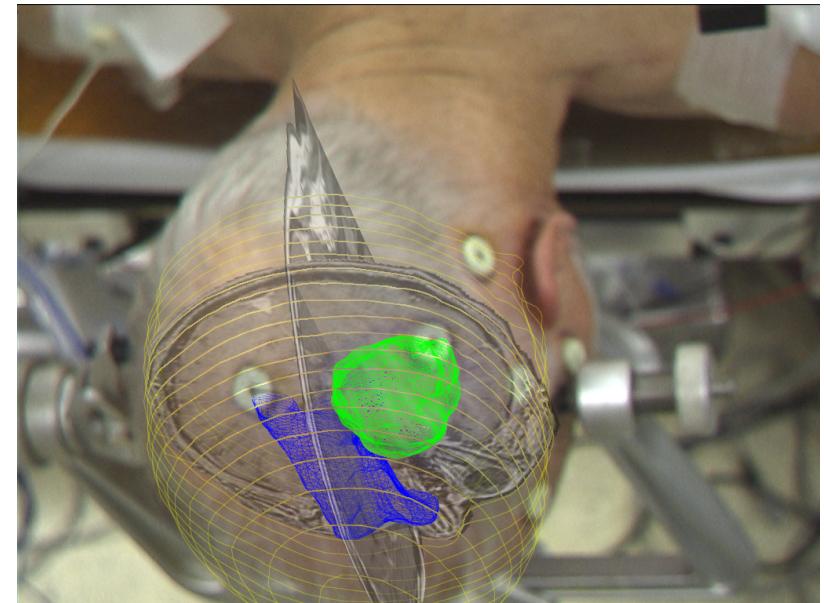
<https://www.youtube.com/watch?v=xthEaobGzs4>

Medical AR Trials

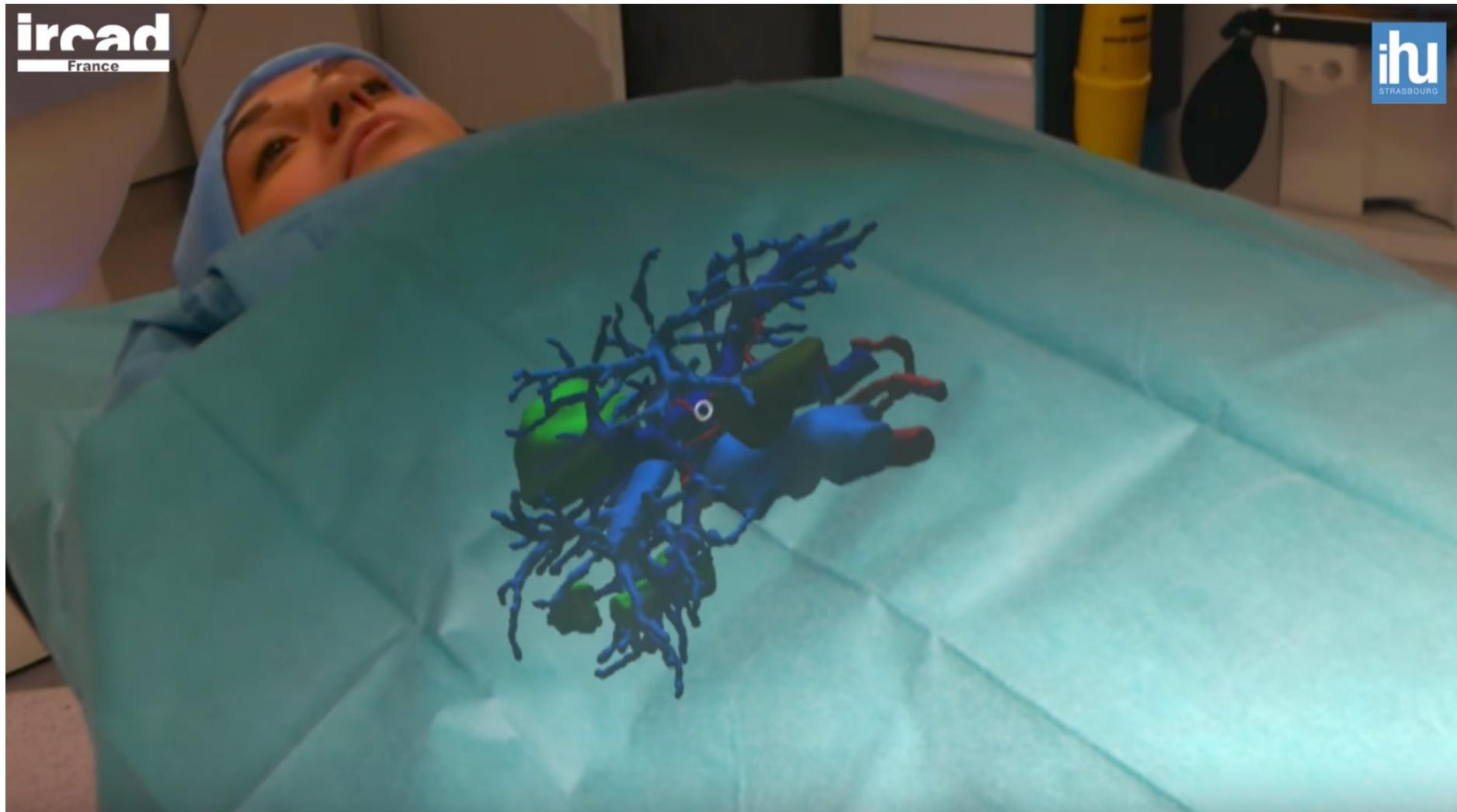
- Sauer et al. 2000 at Siemens Corporate Research, NJ
- Stereo video see through



F. Sauer, Ali Khamene, S. Vogt: An Augmented Reality Navigation System with a Single-Camera Tracker: System Design and Needle Biopsy Phantom Trial, MICCAI 2002



Medical Demo



<https://www.youtube.com/watch?v=kFQuIgeYh7w>

Interactive Museum Experiences

- **BlackMagic**
 - Virtual America's Cup
 - 410,000 people in six months
- **MagicPlanet**
 - TeManawa science museum
 - Virtual Astronomy
 - Collaborative AR experience
- **AR Volcano**
 - Interactive AR kiosk
 - Scienceworks museum, Melbourne



Digital Binocular Station



<http://www.DigitalBinocularStation.com/>

CityViewAR Application



- <https://www.youtube.com/watch?v=fdgrXxJx4SE>

Collaboration Example: Holoportation



- Augmented Reality + 3D capture + high bandwidth
- <http://research.microsoft.com/en-us/projects/holoportation/>

HoloPortation Video



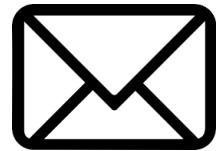
<https://www.youtube.com/watch?v=7d59O6cfaM0>

Summary

- AR technology can be used to develop a wide range of applications
- Promising application areas include
 - Games
 - Education
 - Engineering
 - Medicine
 - Museums
 - Etc..



www.empathiccomputing.org



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