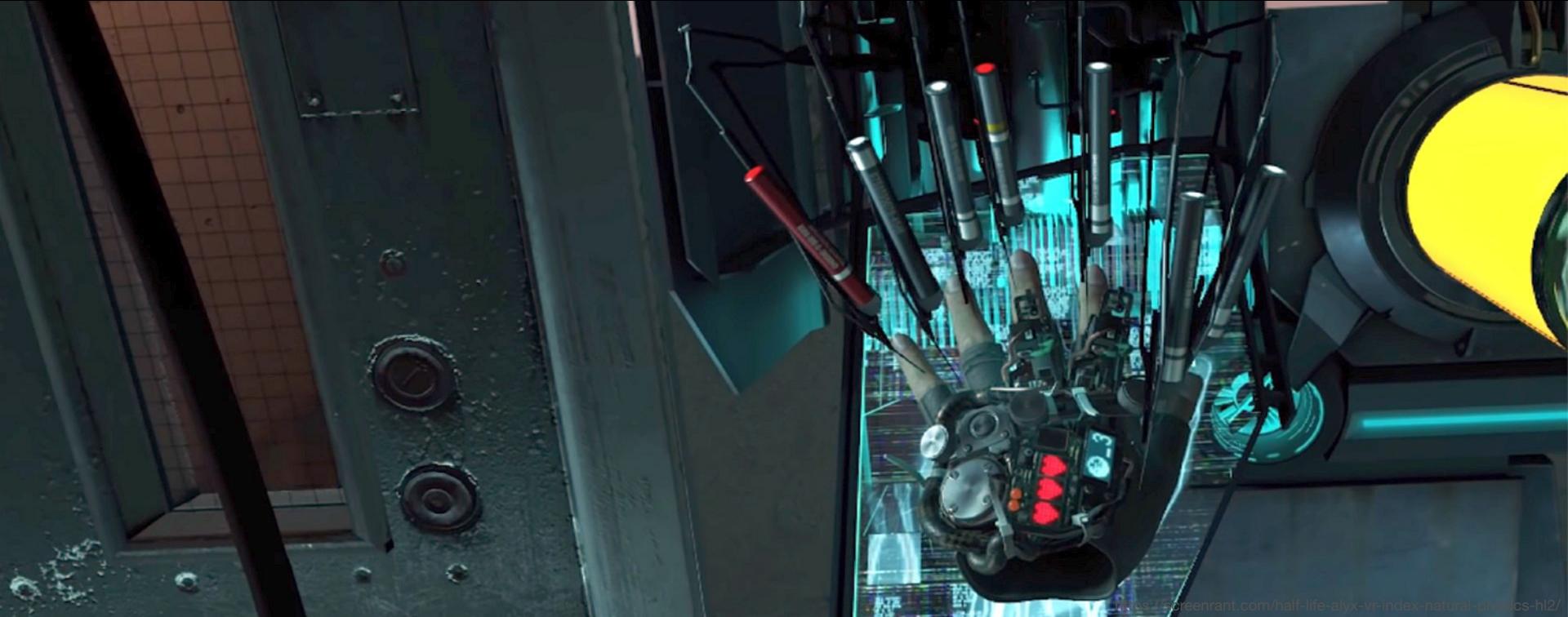


Virtual & Augmented Reality

WS 2025



<https://screenrant.com/half-life-alyx-vr-index-natural-physics-hl2/>

AR Overview

BHT

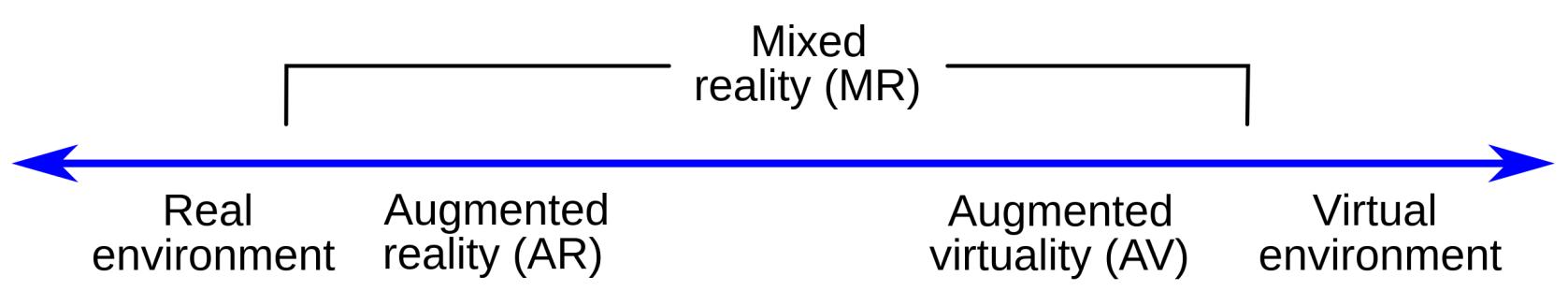


OVERVIEW

- Terms and Definition
 - Brief History
 - Devices
 - Spatial Understanding
-

VIRTUALITY-REALITY CONTINUUM (BY MILGRAM ET AL.)

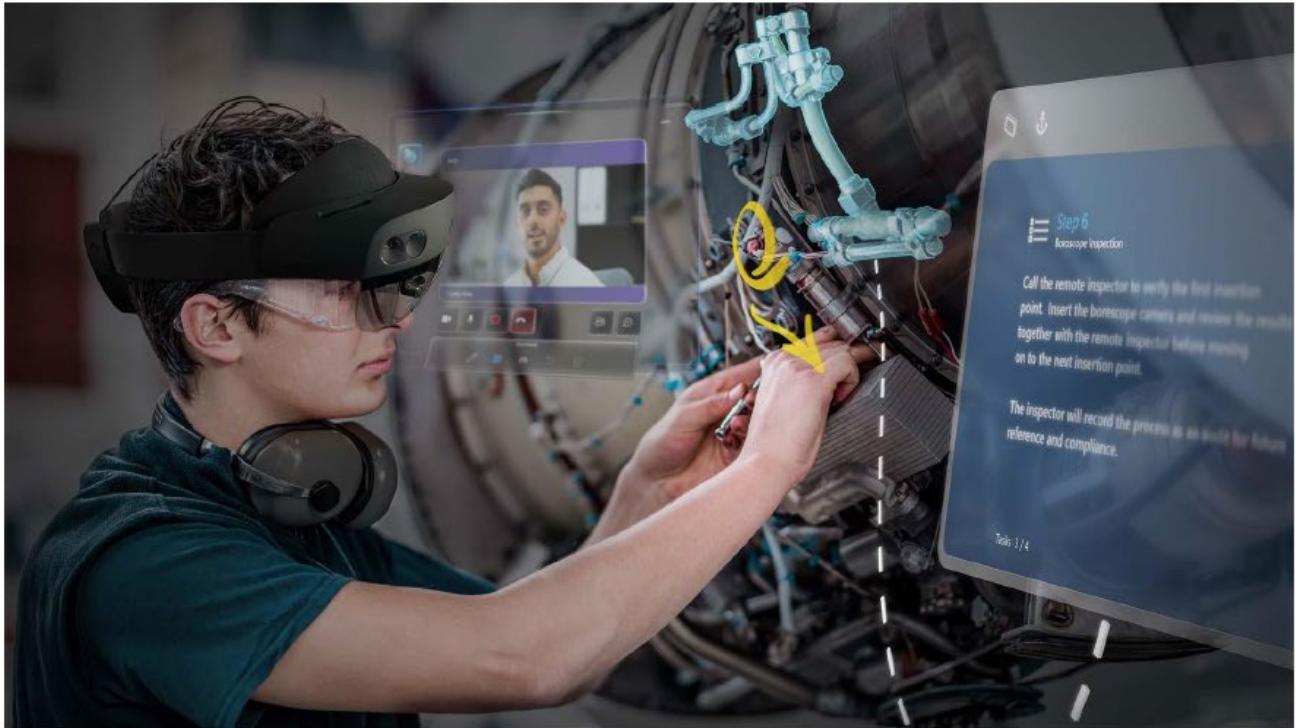
- Mixed Reality (MR) includes AR and AV
- Extended Reality (XR) - AR



THIS IS NOT AR



THIS IS AR



AR DEFINITION

- Combines real and virtual
- Interactive in real time
- Registered in 3-D

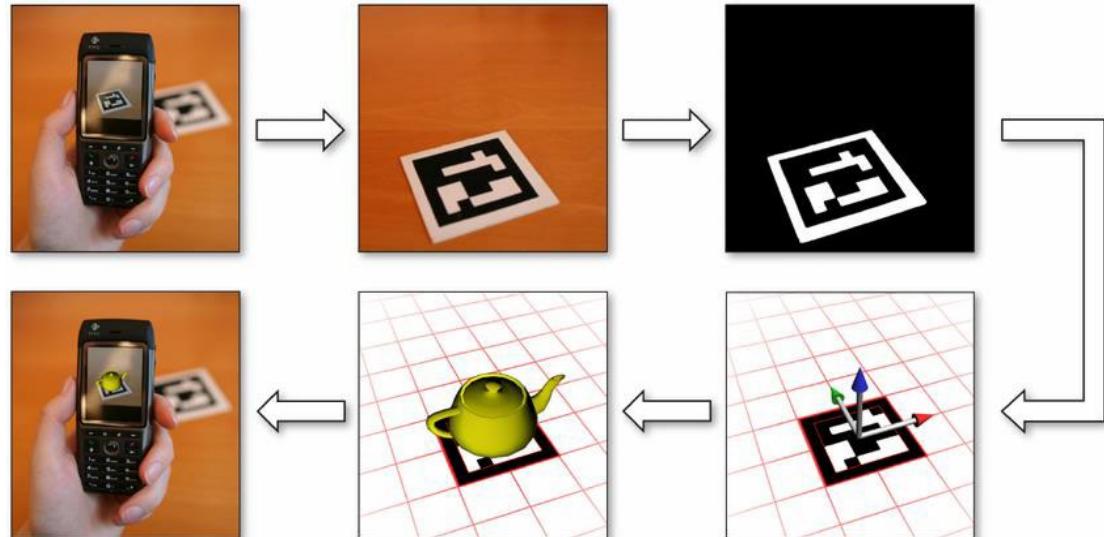
- *Ronald T. Azuma*



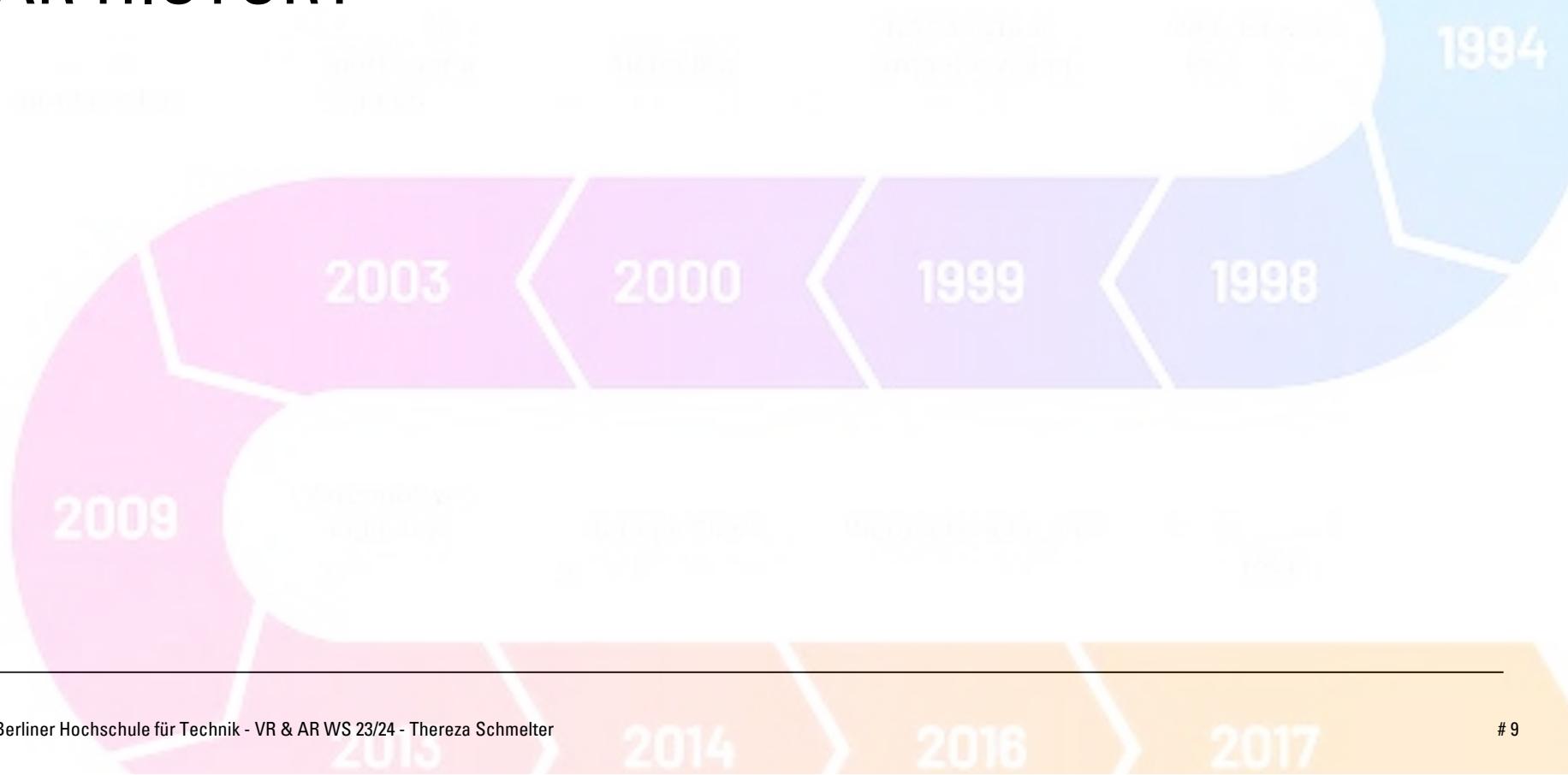
American computer scientist, widely recognized for contributing to the field of augmented reality (AR)

BASIC AR CONCEPT

1. Gain some understanding of the Environment
2. Position virtual Content
3. Display both virtual + real

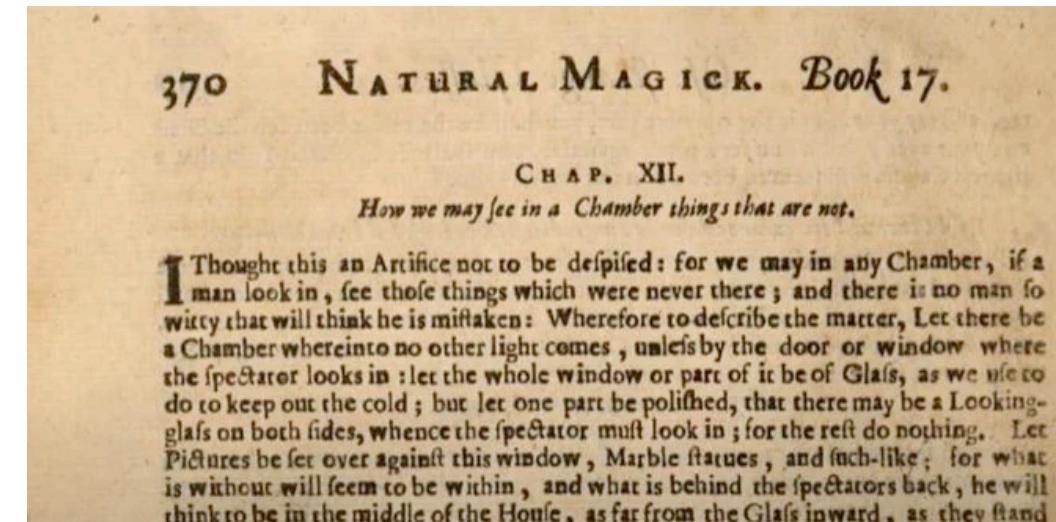


AR HISTORY



FIRST DESCRIPTION

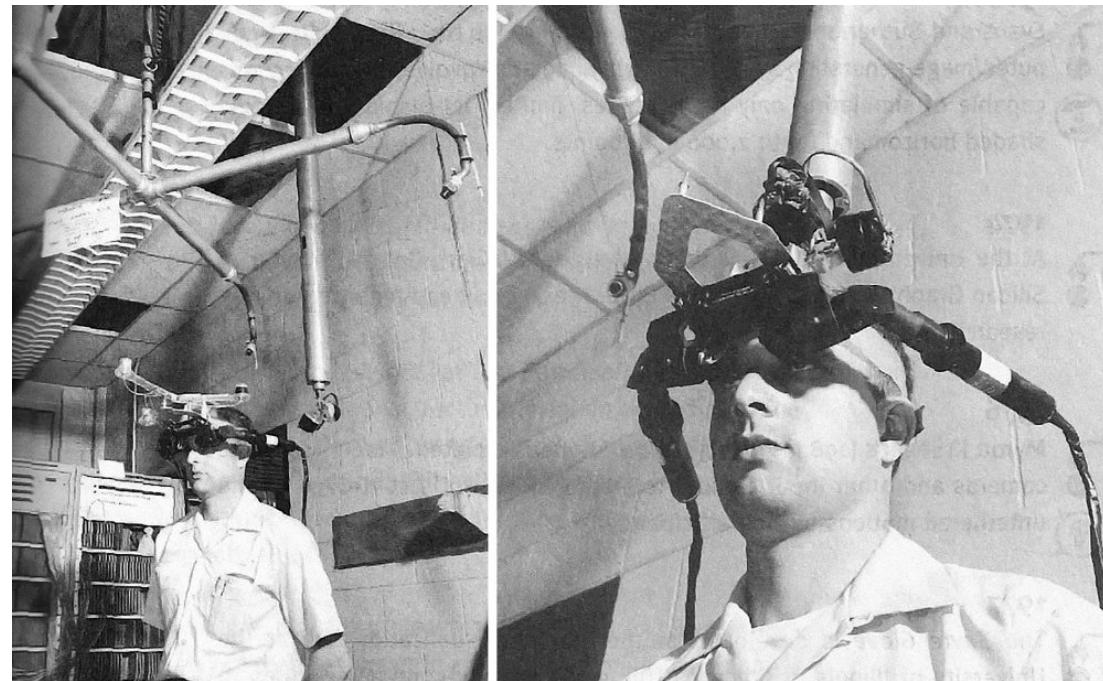
- 1584 Buch „Magia Naturalis“ von Giambattista Della Porta
- beschreibt Glasscheibe, die Objekte in einem anderen Licht und in einer anderen Position reflektiert, so dass es so aussieht, als ob sie sich nicht dort befinden, wo sie tatsächlich sind
- AR rudimentär beschrieben!



HISTORY OF AR – HMD WITH CG IMAGES

- 1969 Sword of Damocles
- First HMD – headset with computer generated images
 - Floating wire frame cube

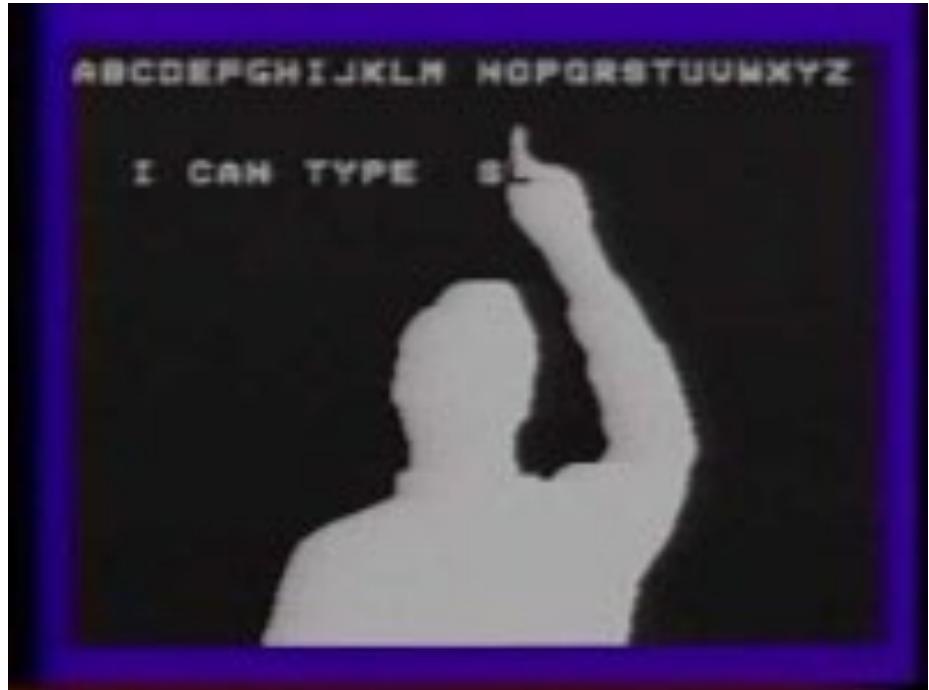
AR and VR were essentially the same concept at this point!



CAMERA PROJECTION INTERACTION

- <https://www.youtube.com/watch?v=d4DUIeXSEpk>

1974 - Myron Kruger, a computer researcher and artist, built a laboratory at the University of Connecticut called 'Videoplace' that was entirely dedicated to artificial reality.



AR IN THE 80S & 90S

- first prototype and term definition
- 1990: Tom Caudell, a Boeing researcher, coined the term ‘augmented reality’.
- 1992: Louis Rosenberg, a researcher in the USAF Armstrong's Research Lab, created ‘Virtual Fixtures’, which was one of the first fully functional augmented reality systems.



First interaction between physical and digital object



FIRST AR IN ENTERTAINMENT

- 1994: Julie Martin, brought augmented reality to the entertainment industry for the first time with the theater production titled *Dancing in Cyberspace*. - the show featured acrobats dancing alongside projected virtual objects on the physical stage.



YELLOW LINE IN FOOTBALL

- 1998: Sportsvision broadcasts the first live NFL game with the virtual 1st & Ten graphic system
 - aka the yellow yard marker. The technology displays a yellow line overlayed on top of the feed to that views can quickly see where the team just advance to get a first down.
- Still used today (with advanced technology)



AR IN THE 2000S

- 2000: Release of ARToolKit (Open-Source Library) for AR Development, library uses video tracking to overlay virtual graphics on top of the real world.
- 2003: Sportvision enhanced the 1st & Ten graphic to include the feature on the new Skycam system – providing viewers with an aerial shot of the field with graphics overlaid on top of it.
- 2009: Esquire Magazine used augmented reality in print media for the first time in an attempt to make the pages come alive. →

Esquire Magazine

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



AR FOR CONSUMER

- 2014: Google presents Google Glass devices, Voice commands
- 2016: Microsoft HoloLens Release
- 2016: Pokemon Go with AR
- 2019: Hololens 2



Microsoft HoloLens 2

AR FOR CONSUMER



AR FOR CONSUMER



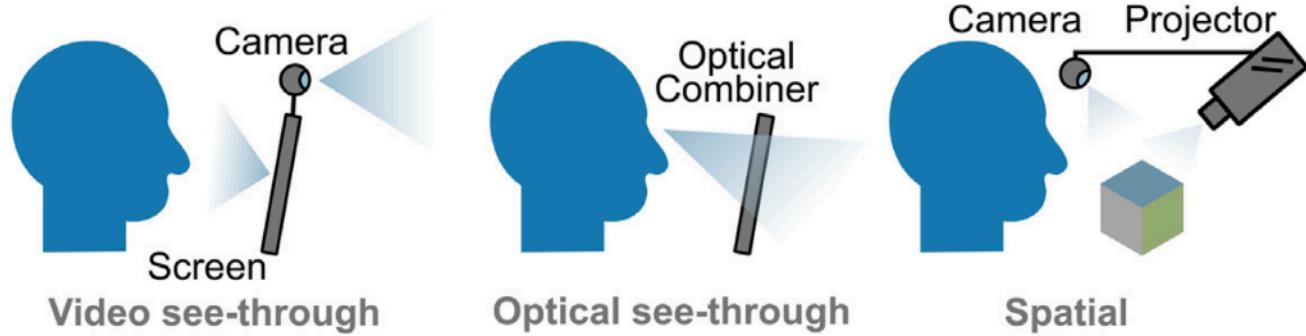
AR TECH AND DEVICES



POSSIBLE PLATFORMS

https://arbook.icg.tugraz.at/schmalstieg/Schmalstieg_398.pdf

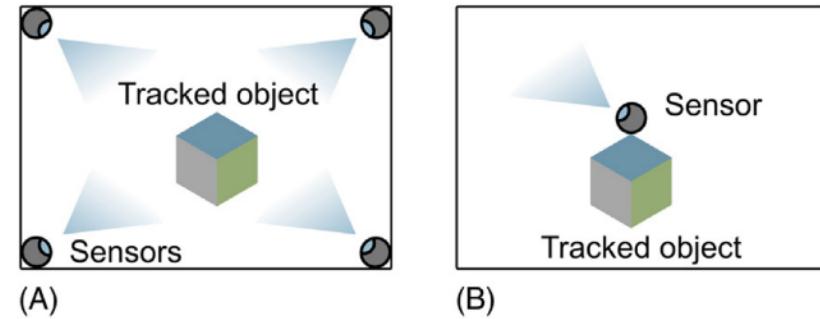
- Handheld AR ~ Mobile AR (Smartphone / Tablet)
- Spatial AR (Projector)
- Head Mounted Display (HMD) AR
 - Optical see through
 - Video see through



HANDHELD AR TECH

https://arbook.icg.tugraz.at/schmalstieg/Schmalstieg_398.pdf

- Similar to HMDs
 - Inside-Out-Tracking for device position/rotation
 - **AND/OR** context-based Tracking (like fiducial markers, faces, planes, ...)
- Similar to video-see-through
 - dotracking/gaininformationaboutthe environment
 - position and render the digital elements
 - set the video-stream as background
 - but only one image rendered (not stereoscopic)



HANDHELD AR DEVICES

- Any common Smartphone/Tablet
 - Android → AR Core (<https://developers.google.com/ar/devices>)
 - iOS → ARKit (iPhone 6S and newer)
- Google Tango (*not supported anymore*)
- iPhone 13/14 Pro, iPad Pro → LiDAR Sensor

LiDAR (*Light detection and ranging*)
dreidimensionales Laserscanning



EXAMPLES

- Handheld AR ~Mobile AR
- (Smartphone / Tablets)



SPATIAL AR TECH

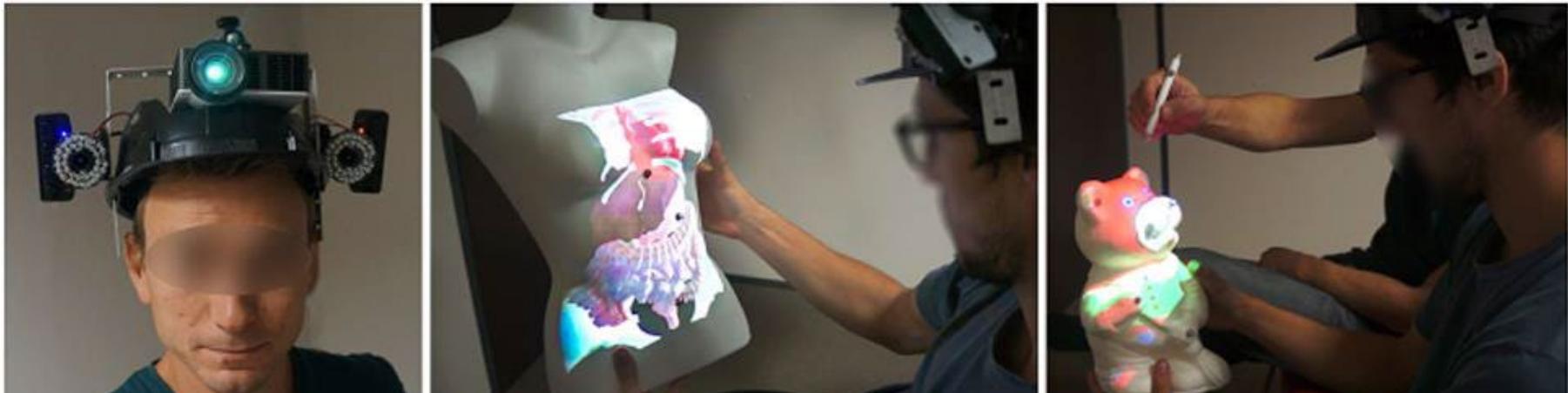
- Projecting on physical space (multiple projectors required to cover full room)
- Mapping of the physical space using InfraRed / LiDAR
- Single user / multiuser
 - either **uncorrected projection** (multiuser)
 - **spatially corrected projection** based on physical space(multiuser)
 - **perspective corrected projection** from single viewpoint(single user >the user's head has to be tracked)



Wilson, A. D., & Benko, H. (2017, May). Holograms without headsets: Projected augmented reality with the RoomAlive Toolkit. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems (pp. 425-428).

POSSIBLE PLATFORMS

- Spatial AR (Projector)



MoSART: Mobile Spatial Augmented Reality for 3D Interaction With Tangible Objects

<https://www.researchgate.net/publication/>

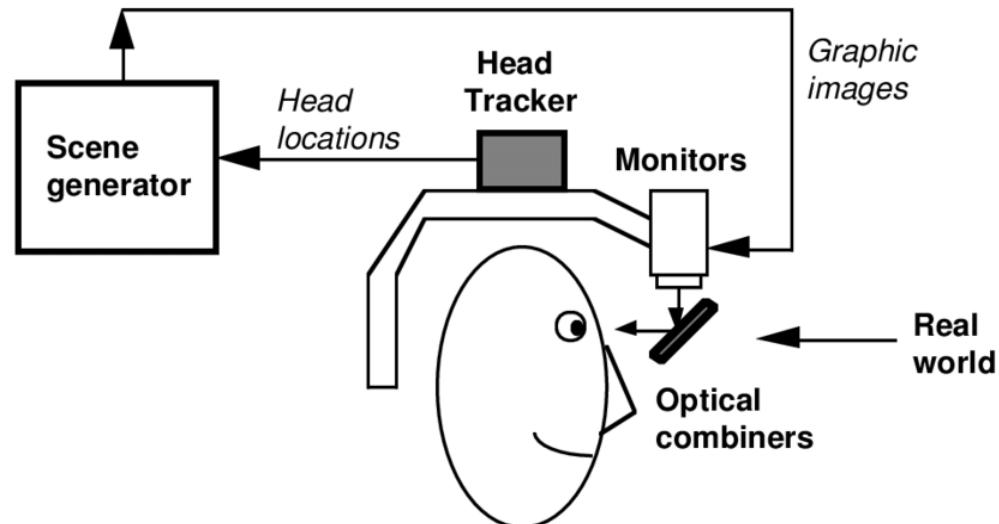
[327116665_MoSART_Mobile_Spatial_Augmented_Reality_for_3D_Interaction_With_Tangible_Objects](https://www.researchgate.net/publication/327116665_MoSART_Mobile_Spatial_Augmented_Reality_for_3D_Interaction_With_Tangible_Objects)

HMD AR TECH

- General
 - two images rendered, one for each eye, high framerate
 - Inside Out Tracking for device position/rotation
- Optical see through
 - render only the digital elements
 - leave the rest empty
- Video see through
 - render the digital elements
 - set the video stream as background

OPTICAL SEE THROUGH

- most realistic approach
- difficult optic systems
- ghostly visuals
- limited control
(environment can't be manipulated)



OPTICAL SEE THROUGH

- Optical See-through HMDs
 - Full functional Headsets (e.g. HoloLens, Magic Leap)
 - Extended AR Screens (e.g. Nreal)



← Usually smartphone as external computing unit



Usually using additional sensoring for world recognition



HMD AR DEVICES OPTICAL SEE THROUGH

- Microsoft HoloLens (1 & 2)
- Magic Leap (1 & 2)
- Google Glass

Google Glasses



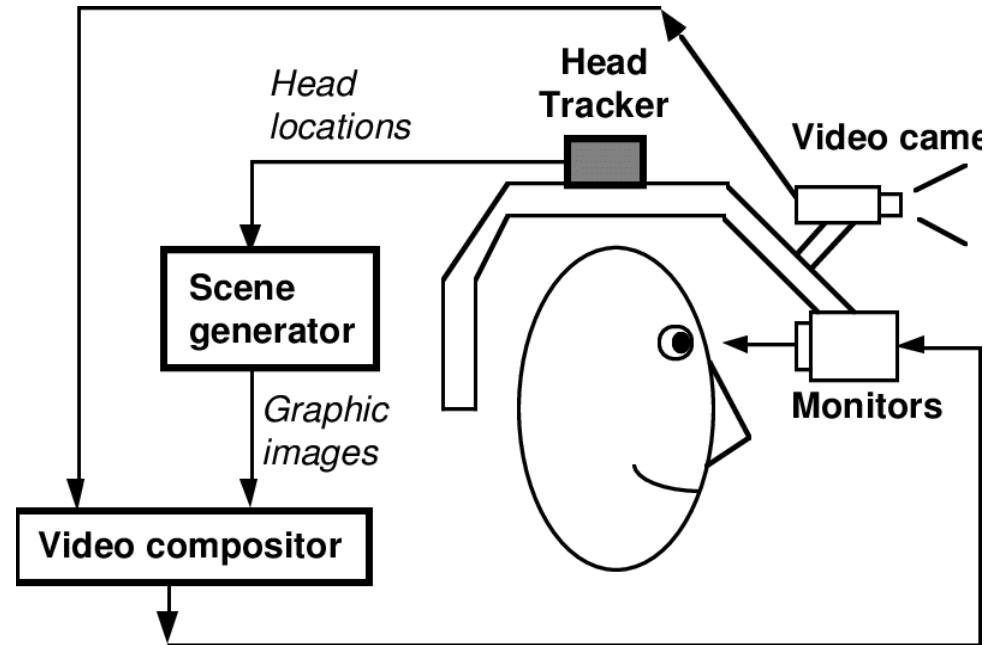
Hololens 2

Hololens 1

Magic Leap

VIDEO SEE THROUGH

- easier to build / use
- can be enabled with VR HMDs
- full control over end-result
(environment can be manipulated)
- *current trend towards video-see-through*



HMD AR DEVICES VIDEO SEE THROUGH

- Meta Quest 2 (only low-res grayscale)
- Meta Quest Pro
- Meta Quest 3
- Pico 4
- Varjo XR-3
- Lynx R1

Quest 2



Quest Pro



EXAMPLES

Nreal Light AR

<https://www.youtube.com/watch?v=QMvfAb4pQ-g>

Meta Quest Pro, see-through warping

<https://www.youtube.com/watch?v=Vh6dVgBDmAM>

Mojo Lens Commercial

<https://www.youtube.com/watch?v=61QNTWE54QU>

