

Introduction

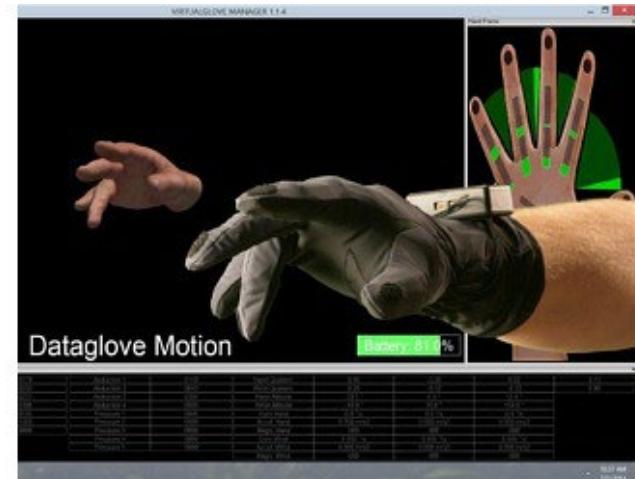
What is Virtual/Augmented Reality?

- Virtual reality and augmented reality
 - Often mentioned together but are very different
 - Computer-generated content
 - Uses sensors and tracking
 - Augmented Reality (AR)
 - Provides textual or graphical information that holds a real-time relationship with one's surroundings
 - Virtual Reality (VR)
 - Complete replacement of visual senses



What is Virtual Reality?

- Virtual reality
 - Conflicting meaning of words *virtual* and *reality*
 - The point of VR is to trick a person's brain into believing something is real
 - The term is often attributed to Jaron Lanier, founder of VPL Research
 - 1987 – developed and sold gear, including goggles and gloves, needed to experience “virtual reality”
 - Dataglove
 - Core concepts and enabling technologies of VR began decades earlier

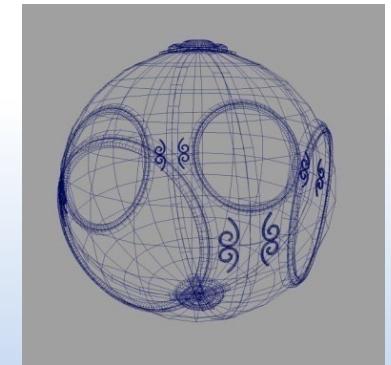
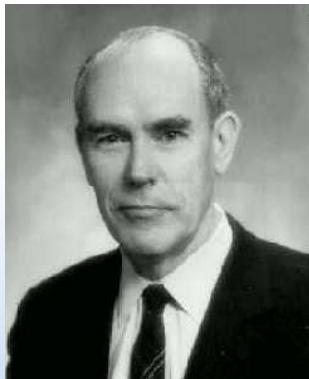


What is Virtual Reality?

- Virtual reality

- Ivan Sutherland

- 1965 – The Ultimate Display, seminal paper
 - 1968 – Sword of Damocles (VR/AR head-mounted display)
 - Large and scary looking contraption
 - Too heavy for any user to comfortably wear and was suspended from the ceiling (hence its name)



What is Virtual Reality?

- Virtual reality
 - Display 3D virtual content
 - Interact with virtual content
 - 3D audio



<https://sites.psu.edu/siowfa15/2015/09/16/does-sitting-too-close-to-the-tv-actually-ruin-your-eyes/>

<https://www.bbc.com/news/technology-54178376>

What is Virtual Reality?

- Virtual reality
 - Provides a user with the sensation of ***immersion*** and ***presence*** within a 3D computer-generated environment
 - Presence – the feeling of “being there”
 - Simulation of visual, auditory and other senses using computing devices
 - Immerse the user in an illusion of reality
 - Computer graphics currently capable of generating images that are indistinguishable from the real-world
 - Detached from real-world surroundings
 - Spatially restricting

What is Augmented Reality?

- Augmented reality
 - The term was coined in 1992
 - By Boeing researchers Tom Caudell and David Mizell
 - Created a see-through head-mounted display to guide assembly of wire bundles for aircraft
 - Registered into the real-time environment by calculating the user's head position



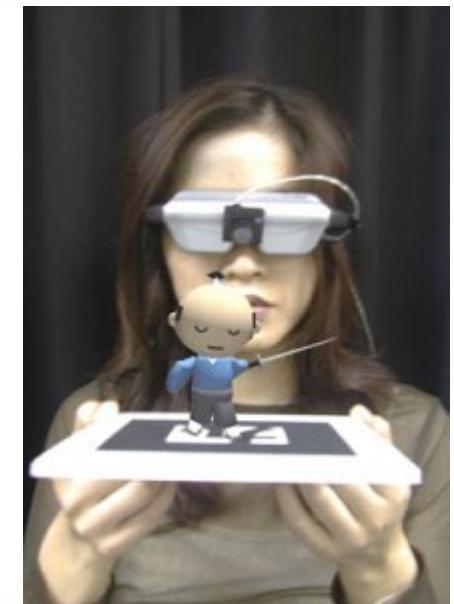
What is Augmented Reality?

- Head-up Displays (HUDs)
 - Transparent display
 - Mounted in front of a pilot
 - Enables viewing with the head positioned “up” rather than looking down at instruments in the cockpit
 - Helmet-mounted displays
 - Moved the display of some information from the HUD to the pilot’s helmet
 - Requires head-tracking
 - Key feature
 - The ability to overlay information onto a pilot’s real-world view



What is Augmented Reality?

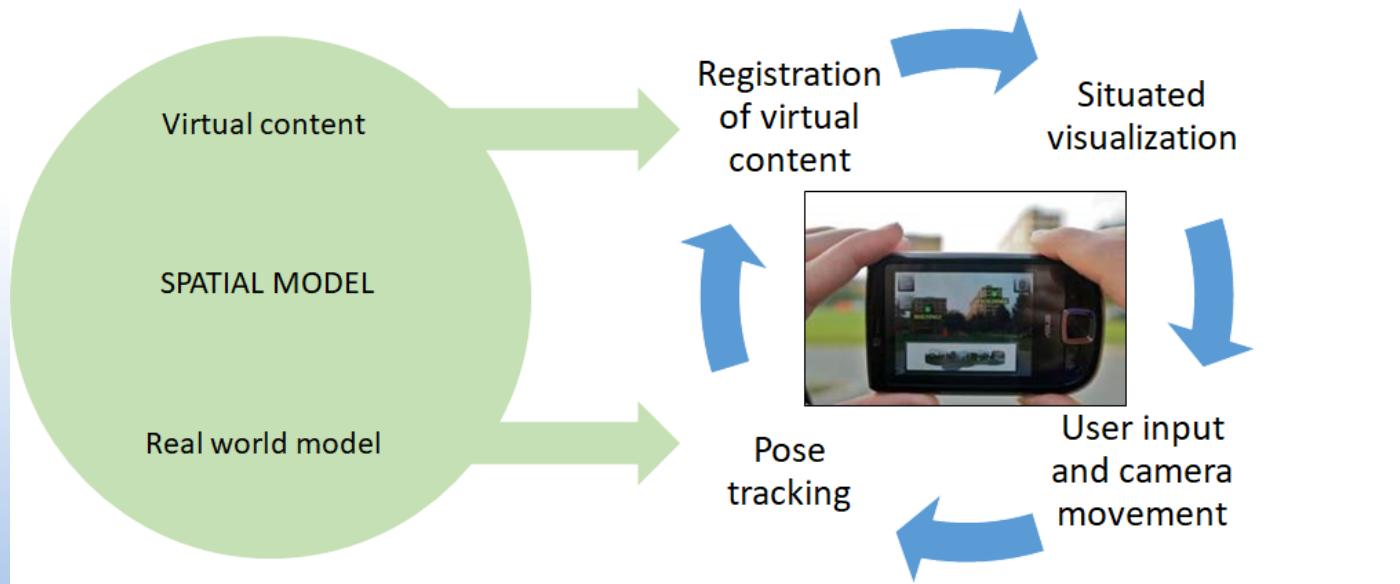
- Augmented reality
 - General term applied to various display technologies
 - Capable of overlaying or combining textual, symbolic or graphical information with a user's view of the real world
 - Must be aligned and correlated to the user's real-world view
 - Azuma's definition
 - Combines real and virtual
 - Interactive in real time
 - Registered in 3D



Ronald T. Azuma. A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments* 1997, 6 (4): 355–385.

What is Augmented Reality?

- AR feedback loop
 - Feedback loop between user and computer
 - The user observes the AR display and controls the viewpoint
 - The system tracks the user's viewpoint, registers the pose in the real world with the virtual content, and presents situated visualisation.



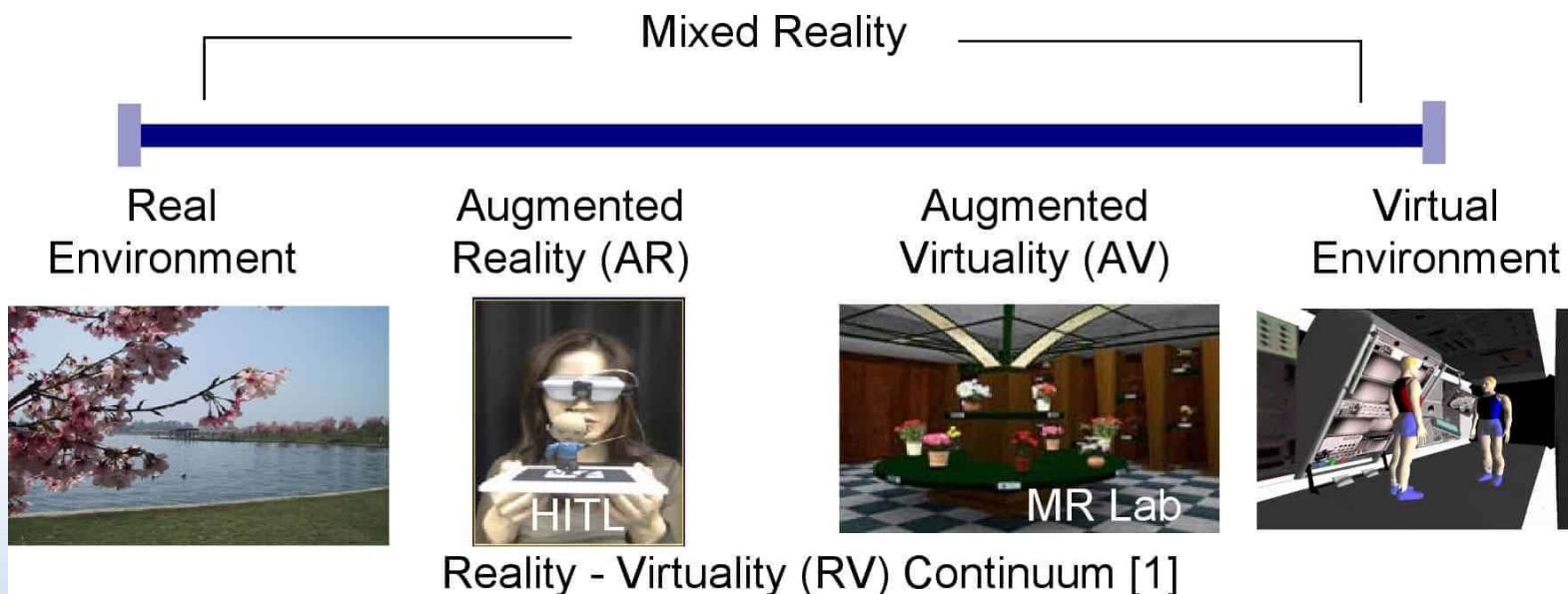
Virtual and Augmented Reality

- VR versus AR

Virtual Reality	Augmented Reality
Intent is to replace reality	Intent is to enhance reality
Users immersed in a completely virtual environment	Virtual content overlaid or combined with user's real-world view
Fully immersive	Non-immersive
Large rendering load	Low rendering load
Requires wide field of view	Small field of view
Less accurate tracking not ideal, but acceptable	Highly accurate tracking required

Reality-Virtuality Continuum

- What is Mixed Reality (MR)?
 - Reality-virtuality continuum represents possible combinations of the real and virtual worlds



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

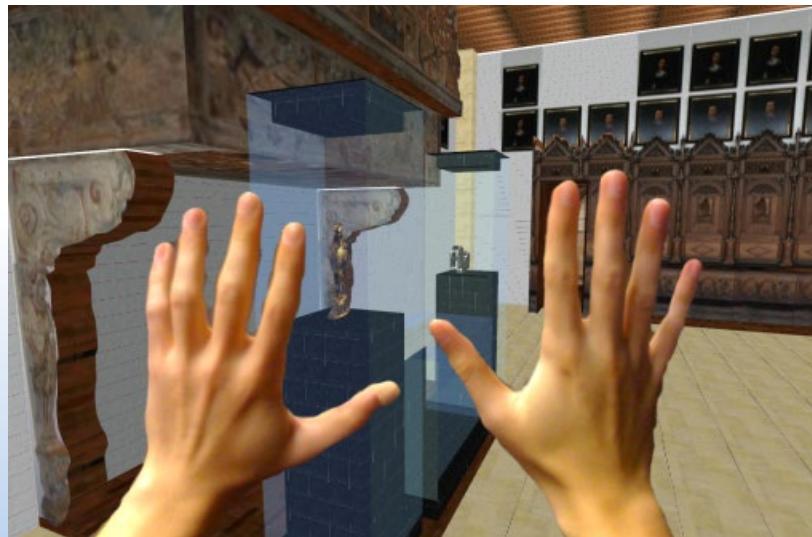
What is Mixed Reality?

- Mixed Reality (MR)
 - Merging of real and virtual environments
 - Virtual information added to MR space and rendered onto the real-world environment in real-time
 - Physical and digital objects co-exist
 - Virtual content and real content able to react to each other in real-time



What is Mixed Reality?

- Augmented virtuality
 - This term is not commonly used
 - Virtual environment that has real-world elements
 - Real-world objects inserted into virtual environments
 - Interaction occurs in virtual space



What is Extended Reality?

- Extended Reality (XR)
 - Umbrella term that includes VR, AR and MR
 - Represents a spectrum of immersive and interactive technologies
 - Some say “X” is a placeholder for all reality-enhancing technologies to come



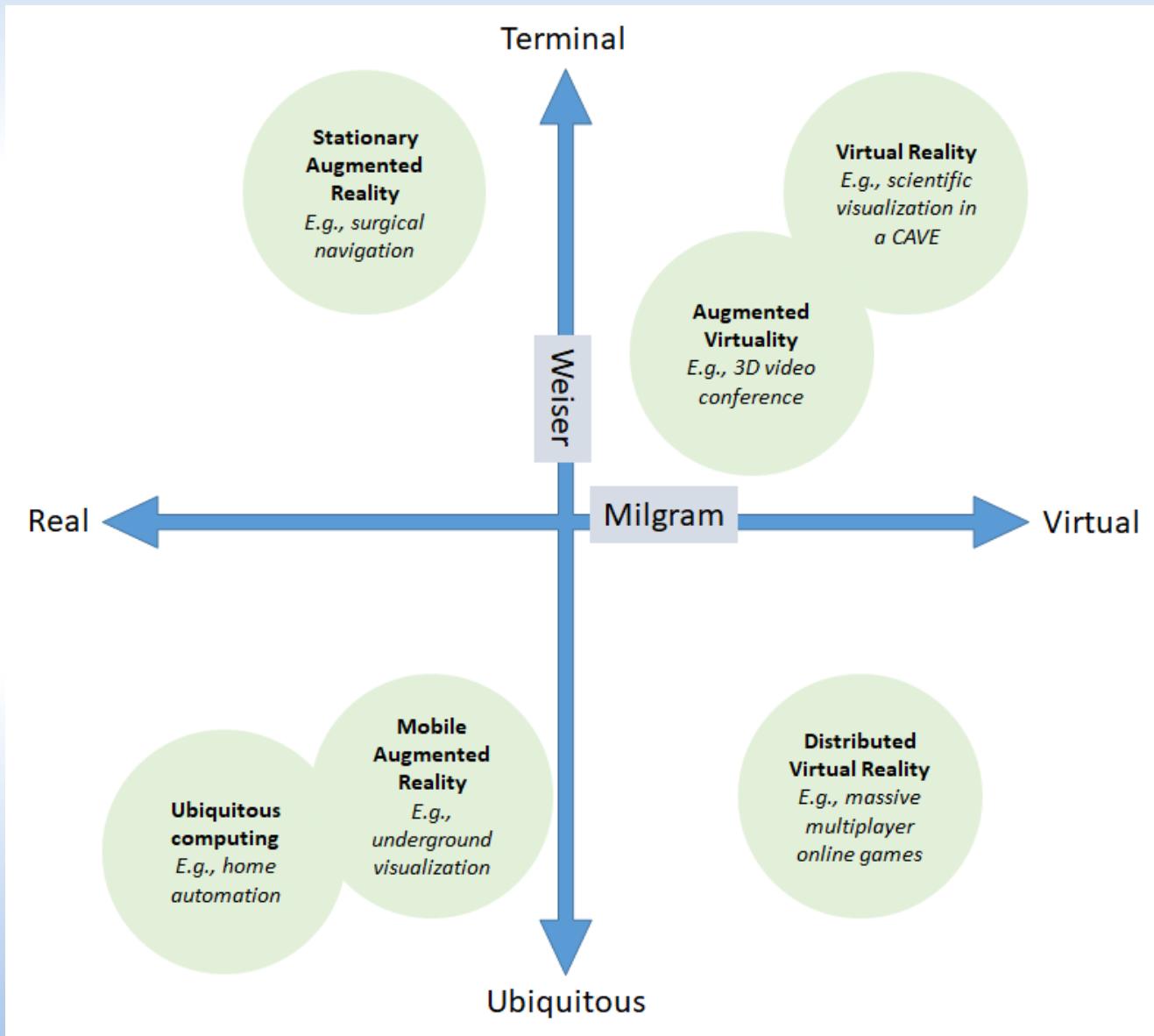
What is Extended Reality?

- Multisensory
 - Five traditional senses
 - Sight
 - Probably the most important of sensory experiences
 - Hearing
 - Immersive 3D audio, location and direction
 - Combination of audio-visual most popular
 - Touch
 - Haptic and feedback technology
 - » Forces, vibrations, resistance, motions
 - Smell
 - Scent cartridges
 - Taste
 - Most difficult

Milgram-Weiser Continuum

- Ubiquitous computing
 - Bringing the virtuality of computer-readable data into the physical world via a variety of compute form factors
 - Human attention is not necessarily required, but at some point control may be necessary
 - Combines virtuality and ubiquity
- The Milgram-Weiser chart
 - Visualises the relationship of various user interface paradigms

Milgram-Weiser Continuum



Noteworthy Events

- Notable events
 - Avatar (2009)
 - 3D viewing experience
 - Oculus Rift (2012)
 - Purchased by Facebook (2014)
 - Google Glass (2013)
 - Windows Mixed Reality (2015)
 - Microsoft HoloLens
 - Meta (2021)
 - Apple Glasses (2025?)



<http://www.impawards.com/2009/avatar.html>

<http://movieline.com/2009/12/new-avatar-set-photo-reveals-how-to-emote-in-blue.php>

<https://www.google.com.au/glass/start/>

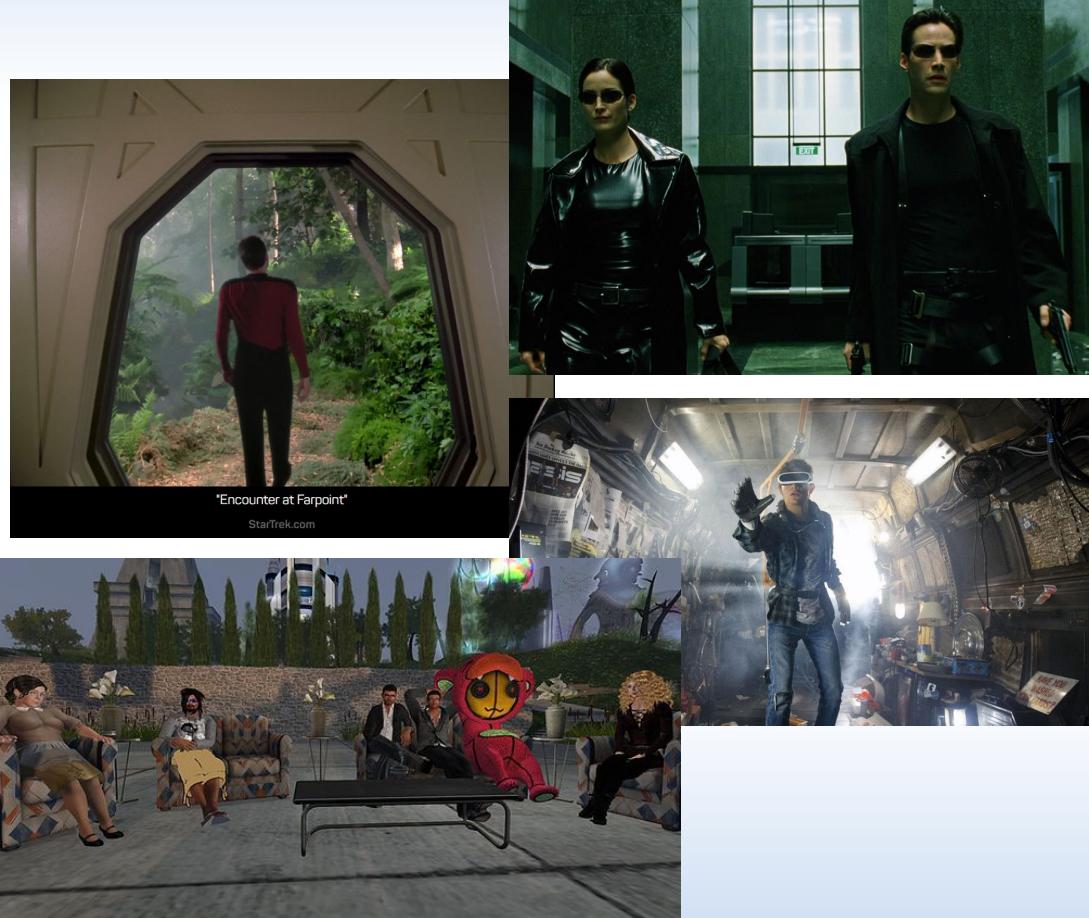
Evan-Amos, Public domain, via Wikimedia Commons

Metaverse

- Metaverse
 - Meta: (Greek) transcendence
 - Verse: short for the universe
- Science fiction novel
 - *Snow Crash* by Neal Stephenson in 1992
- Digital virtual world
 - Parallel to the physical world
 - Persistent and immersive online experience
 - Next-generation Internet
 - XR

Metaverse

- New concept?
 - Movies
 - Star Trek (Holodeck)
 - The Matrix
 - Ready Player One
 - Virtual world
 - Second Life
 - Video games
 - World of Warcraft
 - Minecraft



<https://intl.startrek.com/news/begin-program-the-reality-of-building-a-holodeck-today>

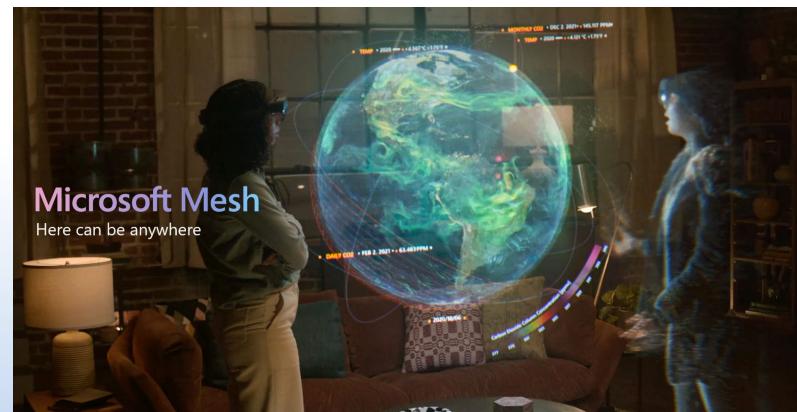
<https://www.bbc.com/culture/article/20180320-film-review-ready-player-one>

https://www.imdb.com/title/tt0133093/mediaviewer/rm3441835264/?ref_=tt_md_2

By HyacintheLuynes - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=33551991>

Metaverse

- Platforms by major companies
 - Meta
 - Horizon Workrooms
 - Immersive meeting space
 - Microsoft
 - AltspaceVR (RIP 2023)
 - Microsoft Mesh
 - Shared presence and experiences
 - Nvidia
 - Omniverse
 - Platform for creating and operating metaverse applications
 - Roblox

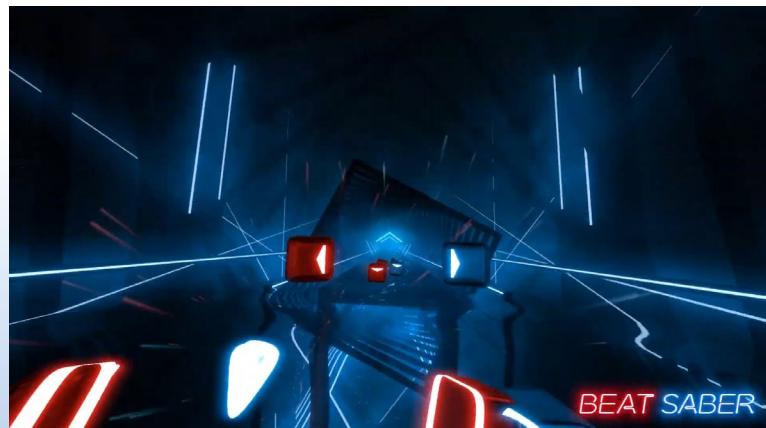


<https://about.fb.com/news/2021/08/introducing-horizon-workrooms-remote-collaboration-reimagined/>

<https://techcommunity.microsoft.com/t5/mixed-reality-blog/microsoft-mesh-a-technical-overview/ba-p/2176004>

Example Applications

- Gaming and entertainment
 - Artistic expression
 - Tilt Brush – paint in 3D space with VR
 - VR gaming
 - Beat Saber – VR rhythm game
 - AR gaming
 - Pokemon Go – AR location-based game



<https://www.tiltbrush.com/>

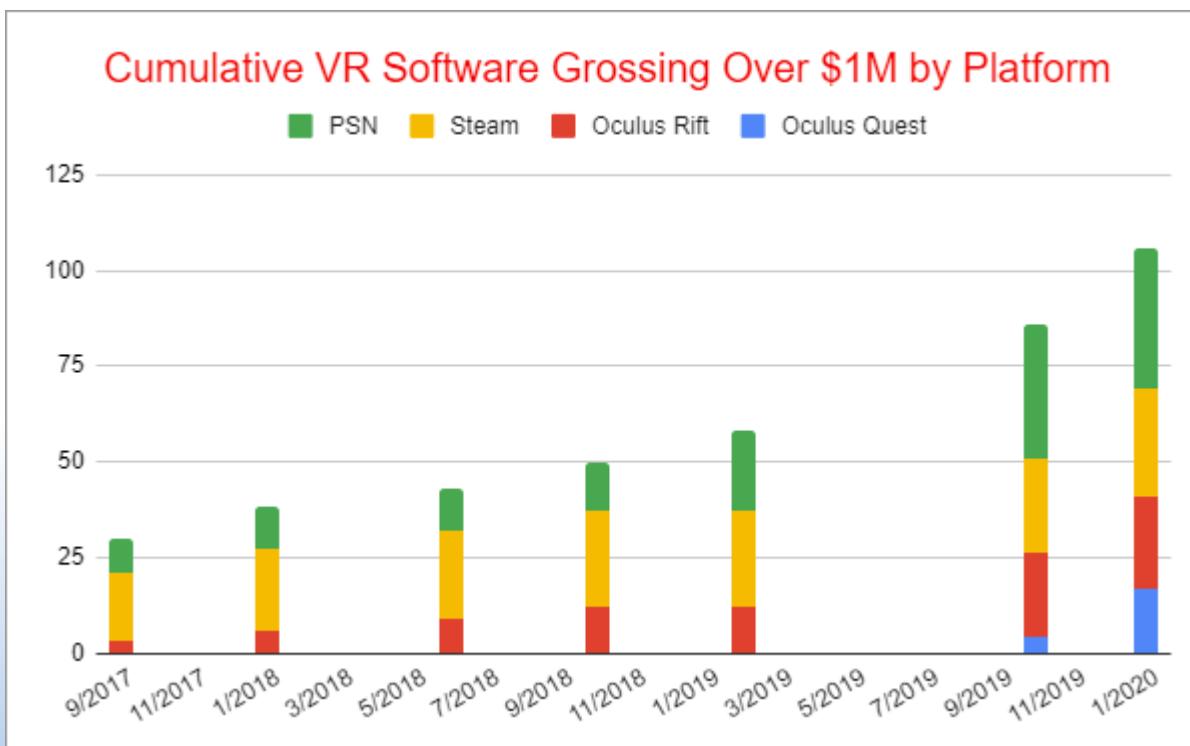
<https://beatsaber.com/>

https://pokemon.fandom.com/wiki/AR_Plus

Example Applications

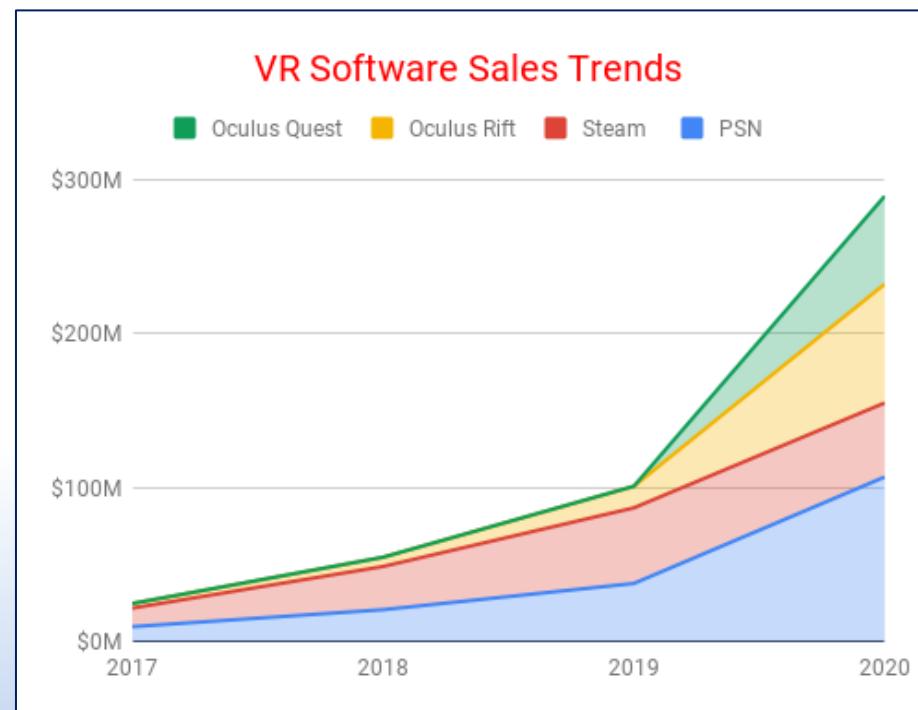
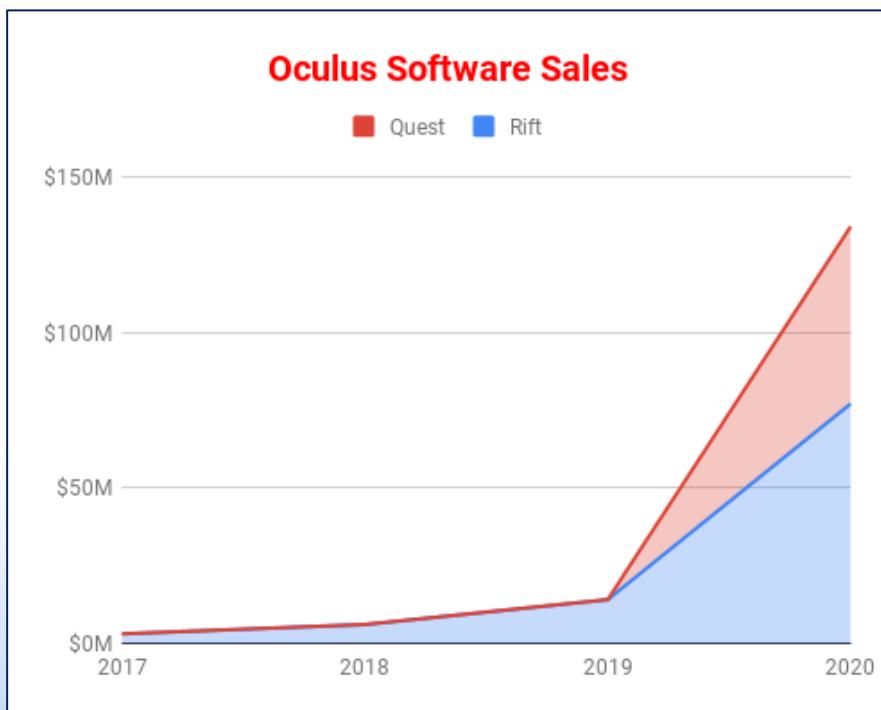
- Gaming and entertainment
 - VR gaming

- Over 100 VR titles exceeded \$1 mil revenue in 2020



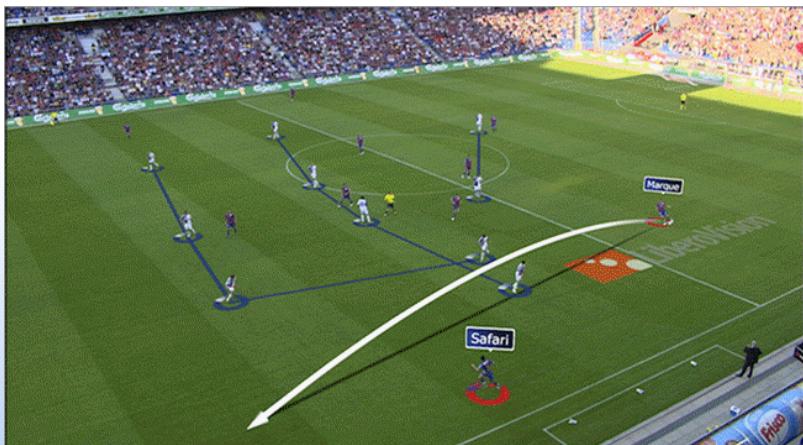
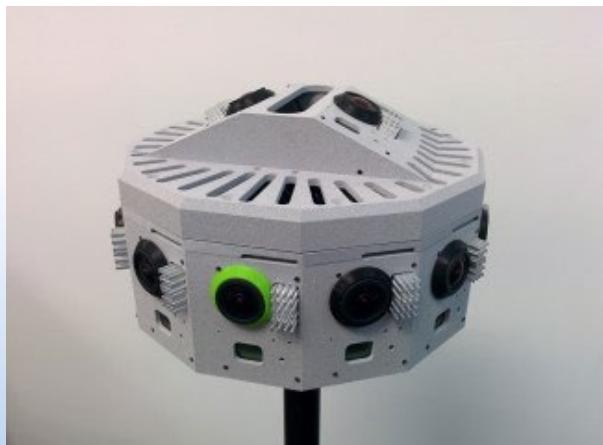
Example Applications

- Gaming and entertainment
 - Headset and software sales



Example Applications

- Gaming and entertainment
 - Immersive video/cinematic VR
 - 360⁰ video
 - Specialised camera systems to capture imagery in all directions
 - Sports, concerts, movies
 - Virtual tours



<https://www.roadtovr.com/jaunt-vr-releases-paul-mccartney-live-let-die-concert-performance-3d-360/>

<https://www.softwaretestinghelp.com/augmented-reality-examples/>

Example Applications

- Gaming and entertainment
 - Fitness gaming
 - Zwift, Peloton
 - Running and biking
 - Wii Fit



Example Applications

- Health and medicine
 - AR overlays on anatomy
 - Rehabilitation
 - Remote training and guidance

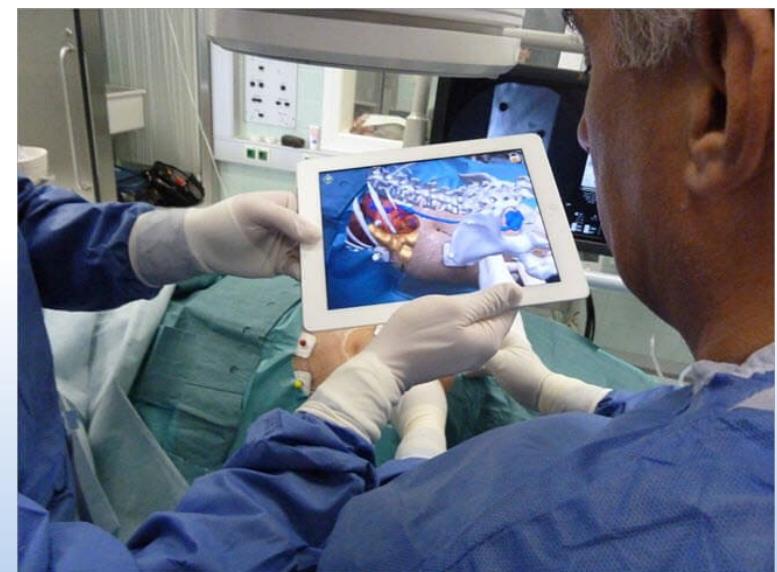


Image: Andrei State, UNC Chapel Hill

<https://gettecla.com/blogs/news/virtual-reality-is-transforming-the-healthcare-and-rehab-industry>

<https://www.softwaretestinghelp.com/augmented-reality-examples/>

Example Applications

- Health and medicine
 - Phobia treatment
 - Pain distraction
 - Dementia learning



Virtual Reality: A Simple yet Interactive Remedy for Phobias and PTSD

<https://agedcareonline.com.au/2017/02/Bupa-Mildura-Among-the-First-to-Experience-Mobile-VR-Dementia-Learning-to-Improve-Quality-of-Life>
<https://medium.com/uxxr/vr-for-pain-distraction-939b7a5b912d>
<https://insightscare.com/virtual-reality-simple-yet-interactive-remedy-phobias-ptsd/>

Example Applications

- Training and education
 - Serious games
 - Vehicle simulators
 - Disaster scenarios



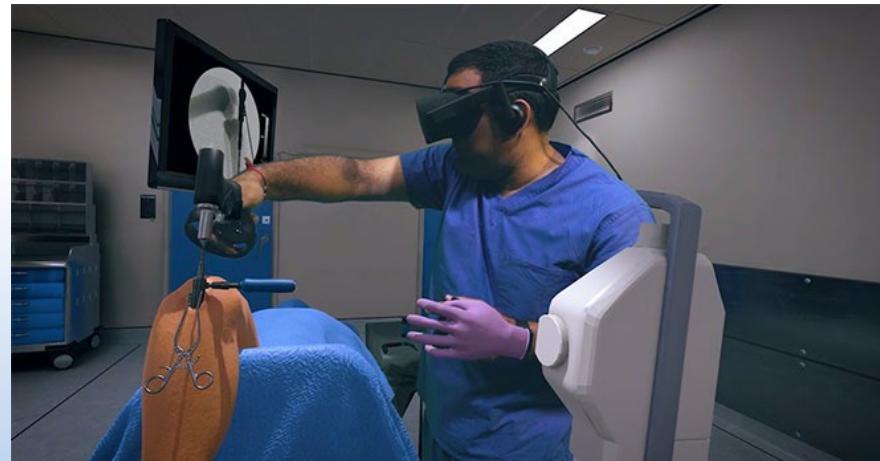
<https://www.auganix.org/bublar-group-partners-with-dafo-to-create-virtual-reality-fire-emergency-training-solution/>

<https://www.roadtovr.com/the-gulf-between-high-end-military-vr-and-consumer-vr-is-rapidly-shrinking/>

<https://www.flyingmag.com/virtual-reality-in-flight-training-more-than-a-fad/>

Example Applications

- Training and education
 - Classroom immersiveness
 - Designing and reviewing
 - Manufacturing processes



<https://www.eduporium.com/blog/eduporium-weekly-ar-and-vr-in-education/>

<https://virtualspeech.com/blog/vr-applications>

Example Applications

- Industry and construction
 - Remote guidance
 - E.g., installations, repairs, and maintenance
 - Construction planning

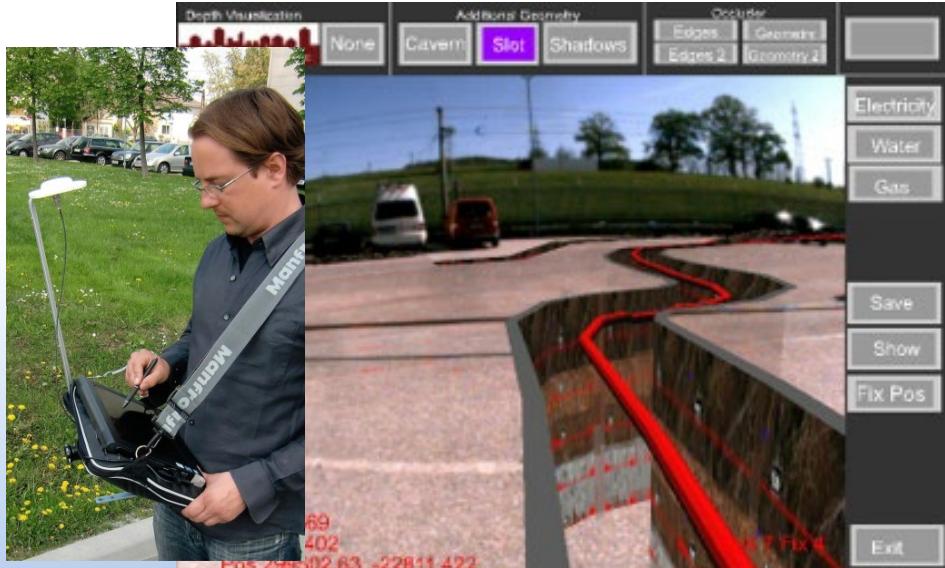


Image: Gerhard Schall

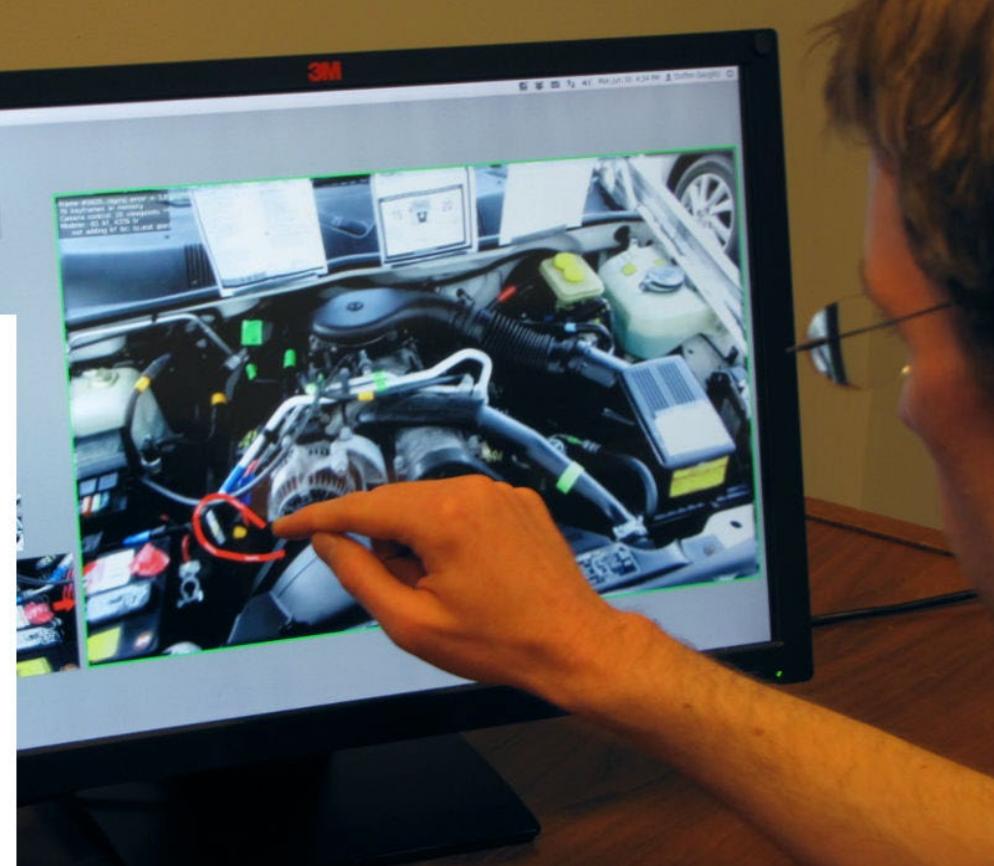
<https://www.scopear.com/solutions/worklink-platform/>

<https://www.pbctoday.co.uk/news/planning-construction-news/vr-in-construction/57709/>

Example Applications



A car repair scenario assisted by a remote expert via AR telepresence on a tablet computer



Remote expert draws hints directly on 3D model of car incrementally transmitted from the repair site

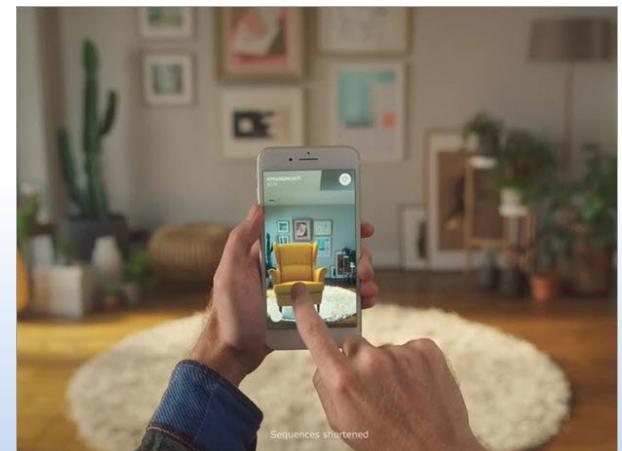
Example Applications

- Real estate
 - Virtual property inspections
- Maintenance
 - Ghost visualisation revealing the interior of a coffee machine to guide end-user maintenance



Example Applications

- Navigation and information
 - AR browser
 - Yelp Monocle superimposes points of interest on a live video feed
 - IKEA Place Lowe and Delux Visualizer
 - Remodel rooms and visualise products



<https://www.caranddriver.com/research/a31995350/self-parking-cars-quick-guide/>

<https://www.softwaretestinghelp.com/augmented-reality-examples>

Example Applications

- Advertising and marketing
 - Pictofit
 - Extracts garment images from shopping sites and renders them to match customer image
 - Modiface
 - Try beauty products and make-up



Open Challenges

- VR and AR issues
 - Cumbersome devices
 - Portability
 - Display resolution and field of view
 - Immersion and presence
 - Expressions, virtual avatars
 - Latency
 - Cost
 - Tracking
 - Registration
 - Health and safety
 - Simulator sickness



References

- Among others, material sourced from
 - <https://www.vrs.org.uk/virtual-reality/history.html>
 - <https://reflectioncreativemedia.com/a-history-of-augmented-reality>
 - <https://amt-lab.org/blog/2021/10/what-is-mr-and-how-does-it-create-exceptionally-immersive-experiences>
 - S. Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Addison-Wesley
 - D. Schmalstieg and T. Hollerer, Augmented Reality: Principles and Practice, Addison-Wesley
 - www.augmentedrealitybook.org
 - R. C. Stevens, Designing Immersive 3D Experiences, New Riders
 - <http://en.wikipedia.org/wiki/>