

Virtual Reality

History of Virtual Reality
Flight Simulators
Immersion, Interaction, Real-time
Haptics

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Virtual reality

“computer-simulated environments that can simulate physical presence in places in the real world, as well as in imaginary worlds”



U.S. Navy personnel using a VR parachute trainer
Source: Wikipedia

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Virtual reality

- One of the “hottest” R&D areas today
- Applications
 - medical training, future surgery?
 - interior design, civil engineering
 - videoconferencing
 - exploration of future worlds
 - ethics, philosophy, psychology, who am I, and what are we?



Source: NASA

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Virtual reality is a “hot” topic today

- Many startup companies
- Games
- Film
- Design (create 3D models, animations in VR)
- Social networks



Oculus VR

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14 grand challenges in engineering (by the US National Academy of Engineering)

- Make Solar Energy Economical
- Provide Energy from Fusion
- Develop Carbon Sequestration Methods
- Manage the Nitrogen Cycle
- Provide Access to Clean Water
- Restore and Improve Urban Infrastructure
- Advance Health Informatics
- Engineer Better Medicines
- Reverse-Engineer the Brain
- Prevent Nuclear Terror
- Secure Cyberspace
- Enhance Virtual Reality
- Advance Personalized Learning
- Engineer the Tools of Scientific Discovery

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History of virtual reality

- 50+ years of history



Link Trainer, 1929
(over 500,000
pilots trained)



Source:
Microsoft

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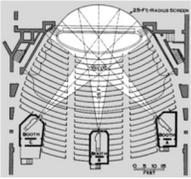
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Cinerama

- Expand movie-going experience by filling a larger portion of the audience's visual field
- Required special cameras to film
- Proved too costly to be embraced by most commercial theaters



"The biggest new entertainment event of the year." - LIFE
1950s



Source: Wikipedia
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Cinerama



How the west was won, 1962 (John Ford)

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Virtual reality and film

- VR heavily influenced by film techniques
- Hollywood, from early 1950s



1982



2009

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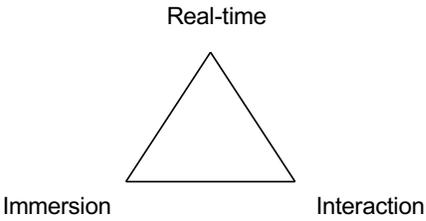
Avatar (2009)



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The virtual reality triangle



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Immersion

- The feeling of "being there"
- User becomes part of the simulated world
- Rather than the simulated world being a feature in the user's world



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Interaction

- Possibility of moving in the virtual space and manipulate objects
- Without it, illusion breaks down quickly



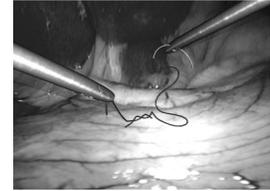
World of Warcraft

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Real-time

- Actions should immediately affect the world
- Computers must simulate the world
- Huge computational burden
- Large computer science challenges



Virtual suturing
Source: Surgical Science

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Head-mounted displays

- Requires **rapid** update rates (min 30 fps, preferably 60 fps)
 - very fast tracking and redisplay
 - short lag times
 - no noticeable delay between movement and production of correct visuals
- if these are not satisfied => **simulator sickness**



Source: Atticus Graybill of Virtually Better, Inc.

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Head-mounted displays



Playstation VR (Sony)



Oculus Rift (Facebook)

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Head-mounted displays



HTC Vive (HTC and Valve)



Google Cardboard (Google)

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Requirements for virtual reality

- 3D stereoscopic display



- Wide field of view display (e.g., 100-110 degrees)
- Low latency head tracking (Oculus: 30 msec)

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Tracking

- Head: gyroscope, accelerometer, LED lights + external camera
- Hands, body: invisible infrared laser, external cameras
- “Outside-in” vs “Inside-out”
- Eye tracking: using infra-red sensors
 1. correct depth of field
 2. know where the user is looking

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Cave

- Project 3D CG into a cube with displays surrounding the viewer
- Coupled with head tracking systems (and other tracking systems e.g. hand)
- Usually surround audio feedback
- Viewer explores virtual world by moving and interacting in the virtual environment



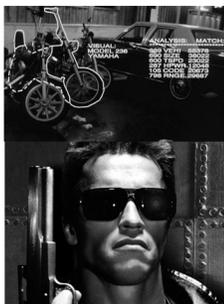
Source: Dave Pape

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Augmented reality

- Enhances your reality with graphics, haptics, sound



Source: bestofmicro.com, cultofandroid.com

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Augmented reality headsets



HoloLens (Microsoft) (2016)
HoloLens 2 (2019)

Magic Leap One (2018)
Magic Leap 2 (2022)

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Augmented reality headsets



Apple Vision Pro (2024)



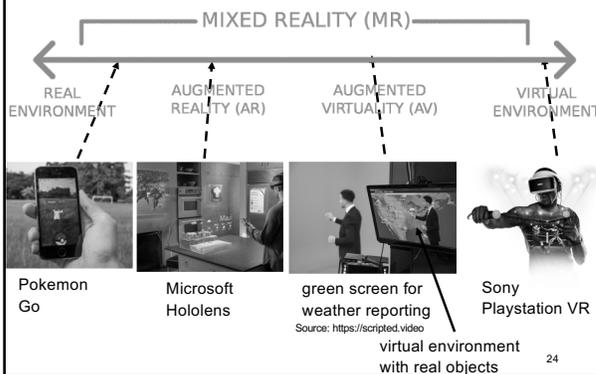
Pass-through technology



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The different realities



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Virtual Reality vs Augmented Reality

	Virtual Reality	Augmented Reality
Modeling complexity	Requires high-resolution models	Not so demanding as VR
Display technology	Wide field of view	Can be narrow field of view
Tracking	Not as demanding as AR	Must be high-quality

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Virtual reality "hardware"

Source: Dave Pape (VPL Research; Jaron Lanier) Source: Mario Tama, Getty Images Source: VirtuSphere

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HoloTile (Disney Imagineering, 2024)

Source: LA Times

Lanny Smoot, inventor of Disney's HoloTile technology, has 106 patents to his name. (Christian Thompson / Disneyland Resort)

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Flight simulators

- Key driving force of virtual reality technologies
- US Air Force, NASA
- Friend/foe identification
- Targeting/threat information
- Optimal flight path

Source: NASA

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Flight simulators

- Must manage and render the virtual world
- Shadows and textures
- Motion and force feedback
- Professional flight simulators are still very expensive (millions of \$)

Thales flight simulator
Source: Wikipedia

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Train simulation

Fujitsu train simulator (2008)

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Tank simulator



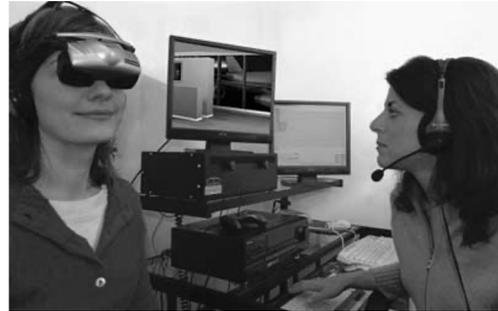
Stryker armored vehicle simulator

Source: Jason Kaye, U.S. Army

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Application in medicine: Phobia treatment



Source: Virtually Better, Inc.

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Application in medicine: Phobia treatment



Source: Virtually Better, Inc.

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Application in TV and sports



First-down line
Source: SporTVision

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Haptic interfaces

- hap-tic ('hap-tik)
adj.
Of or relating to the sense of touch; tactile.



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Force-feedback rendering



Phantom 3-DoF device
(Sensable)



Force-feedback mouse
(Immersion)

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Force-feedback rendering

Adaptive 6-DoF Haptic Contact Stiffness Using the Gauss Map

Hongyi Xu Jernej Barbic

Xu and Barbic 2016

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Simulation in games



Silent Hunter 4 (Ubisoft)

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Virtual reality in games



Source: Colin Anderson

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Discussion

- Can we simulate anything?
- What is reality?



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Why virtual worlds?



Leontopodium alpinum
Source: appolonio&battista

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