

Virtual Reality

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

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1

1

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

2

2

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

3

3

Virtual reality is a “hot” topic today

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



Oculus VR

4

4

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

5

5

History of virtual reality

- 50+ years of history



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



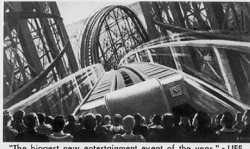
Source:
Microsoft

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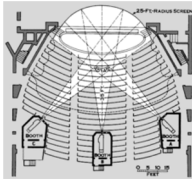
6

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
7

7

Cinerama




How the west was won, 1962 (John Ford)

8


8

Virtual reality and film

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



1982




2009

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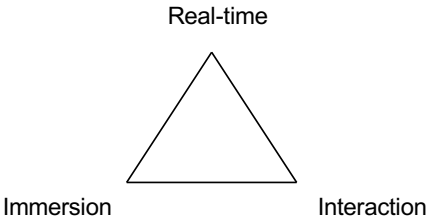
Avatar (2009)



10

10

The virtual reality triangle




11

11

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



12

12

Interaction

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



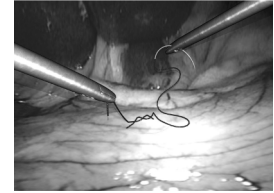
World of Warcraft

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13

Real-time

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



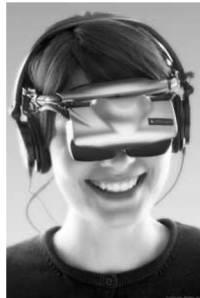
Virtual suturing
Source: Surgical Science

14

14

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.

15

15

Head-mounted displays



Playstation VR (Sony)



Oculus Rift (Facebook)

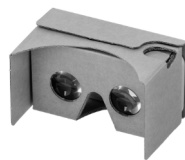
16

16

Head-mounted displays



HTC Vive (HTC and Valve)



Google Cardboard (Google)

17

17

Requirements for virtual reality

- 3D stereoscopic display



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

18

18

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

19

19

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



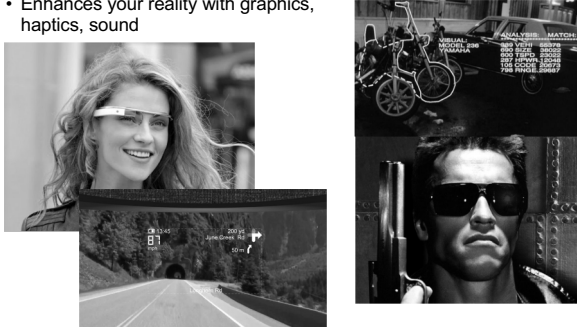
Source: Dave Pape

20

20

Augmented reality

- Enhances your reality with graphics, haptics, sound




Source: bestofmicro.com, cultofandroid.com

21

21

Augmented reality headsets



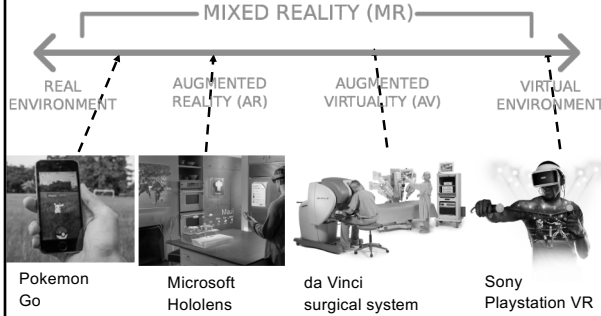
Microsoft HoloLens (Microsoft); released HoloLens 2 in Feb 2019

Magic Leap One (Aug 2018) (Magic Leap)

22

22

The different realities



← MIXED REALITY (MR) →

REAL ENVIRONMENT AUGMENTED REALITY (AR) AUGMENTED VIRTUALITY (AV) VIRTUAL ENVIRONMENT

Pokemon Go Microsoft HoloLens da Vinci surgical system Sony Playstation VR

23

23

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

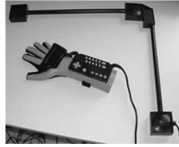
24

24

Virtual reality "hardware"



Source: Dave Pape (VPL Research; Jaron Lanier)



Source: Mario Tama, Getty Images



Source: VirtuSphere

25

25

Flight simulators

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



Source: NASA

26

26

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

27

27

Train simulation

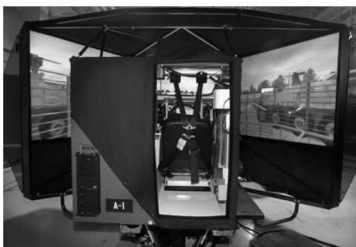


Fujitsu train simulator (2008)



28

Tank simulator



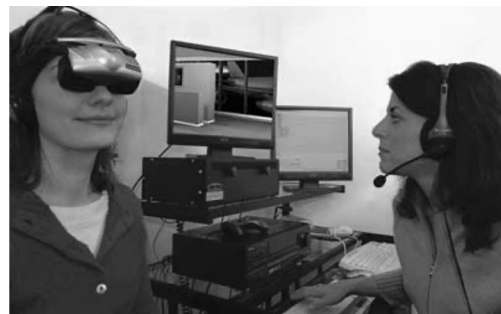
Stryker armored vehicle simulator

Source: Jason Kaye, U.S. Army

29

29

Application in medicine: Phobia treatment



Source: Virtually Better, Inc.

30

30

Application in medicine: Phobia treatment

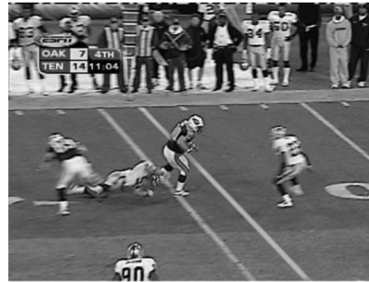


Source: Virtually Better, Inc.

31

31

Application in TV and sports



First-down line
Source: SporTVision

32

32

Haptic interfaces

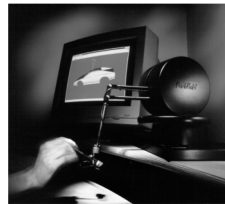
- hap-tic ('hap-tik)
adj.
Of or relating to the sense of touch; tactile.



33

33

Force-feedback rendering



Phantom 3-DoF device
(Sensable)



Force-feedback mouse
(Immersion)

34

34

Force-feedback rendering

**Adaptive 6-DoF Haptic Contact Stiffness
Using the Gauss Map**

Hongyi Xu Jernej Barbic

Xu and Barbic 2016

35

35

Simulation in games



Silent Hunter 4 (Ubisoft)

36

36

Virtual reality in games



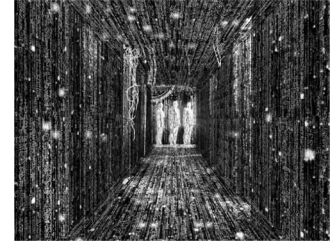
Source: Colin Anderson

37

37

Discussion

- Can we simulate anything?
- What is reality?



38

Why virtual worlds?



Leontopodium alpinum
Source: appolonio&battista

39

39