CSCI 420 Computer Graphics
Lecture 25

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

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

Virtual reality is a “hot” topic today

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

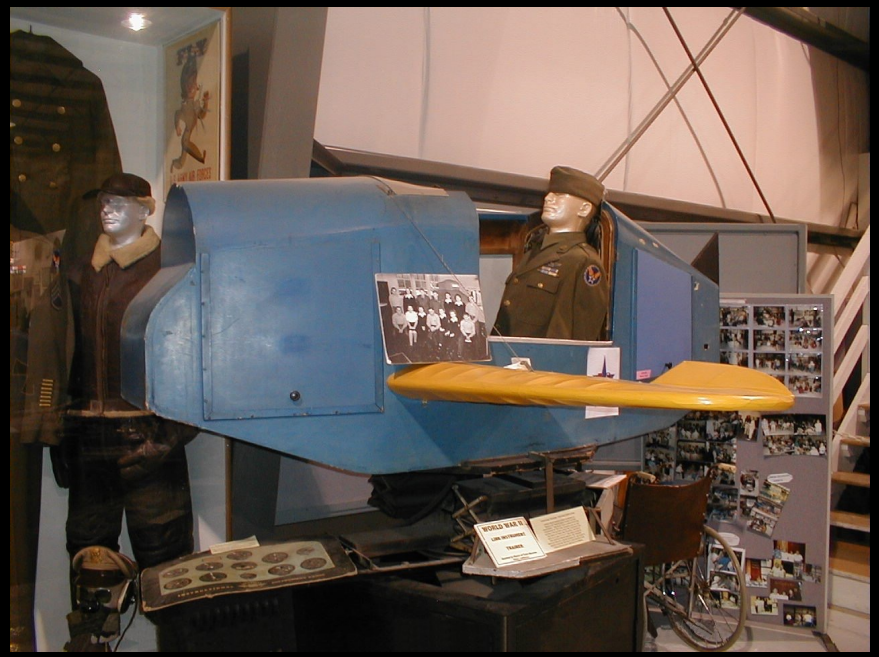
Oculus VR

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

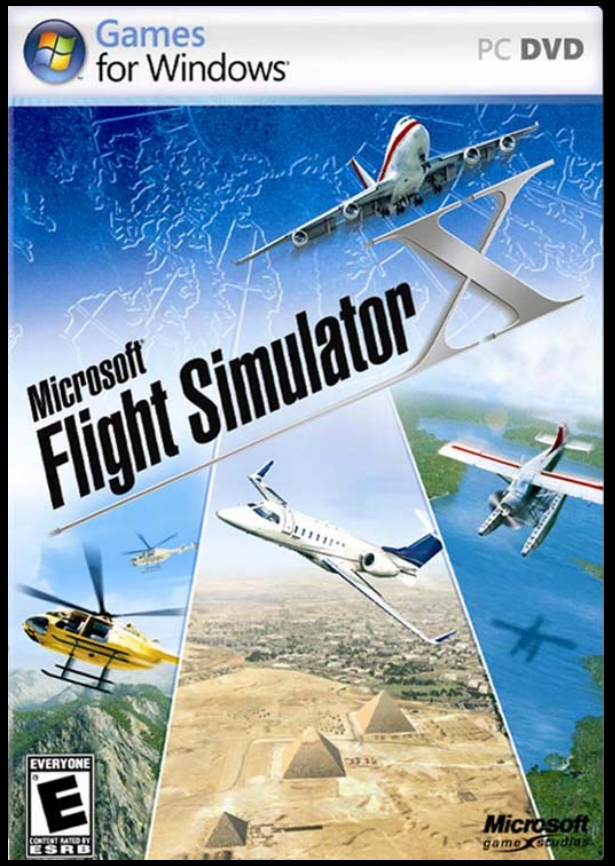
- Make Solar Energy Economical
- Provide Energy from Fusion
- Develop Carbon Sequestration Methods
- Manage the Nitrogen Cycle
- Provide Access to Clean Water
- Restore and Improve Urban Infrastructure
- Advance Health Informatics
- Engineer Better Medicines
- Reverse-Engineer the Brain
- Prevent Nuclear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

History of virtual reality

- 50+ years of history



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

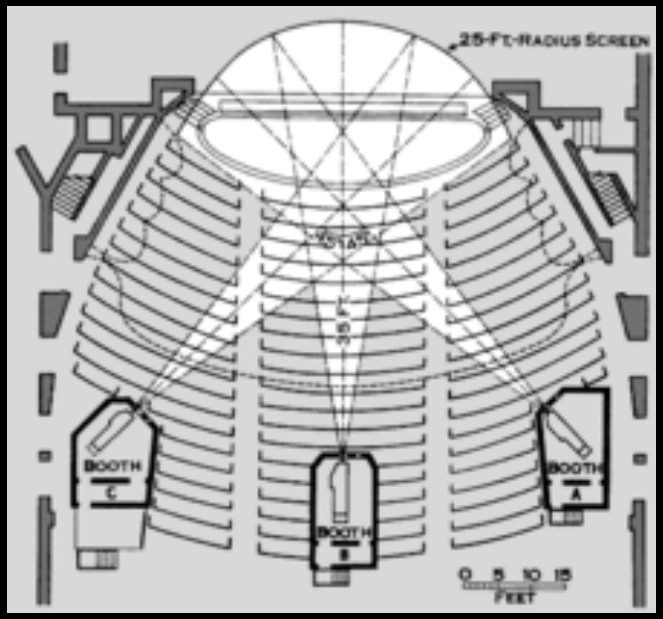


Source:
Microsoft

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

1950s



Source: Wikipedia

Cinerama

How the west was won, 1962 (John Ford)

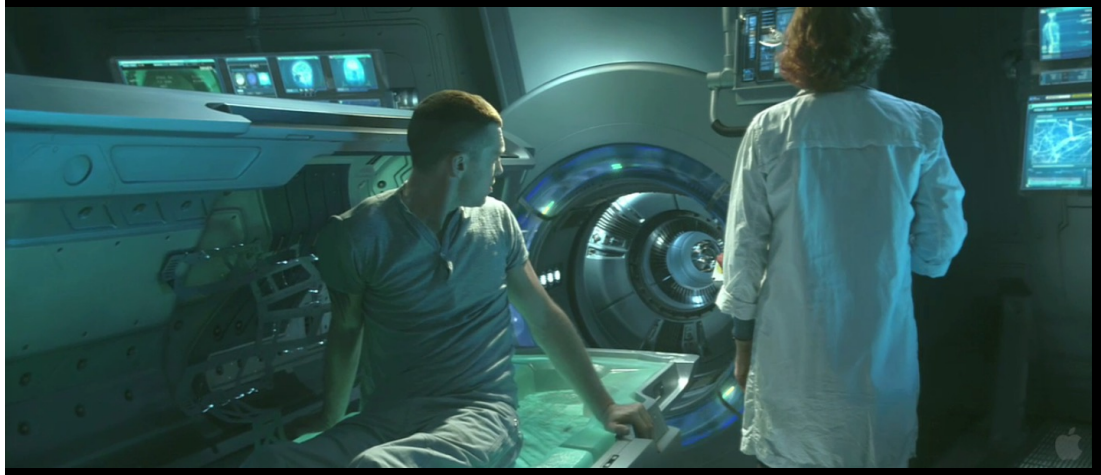
Virtual reality and film

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

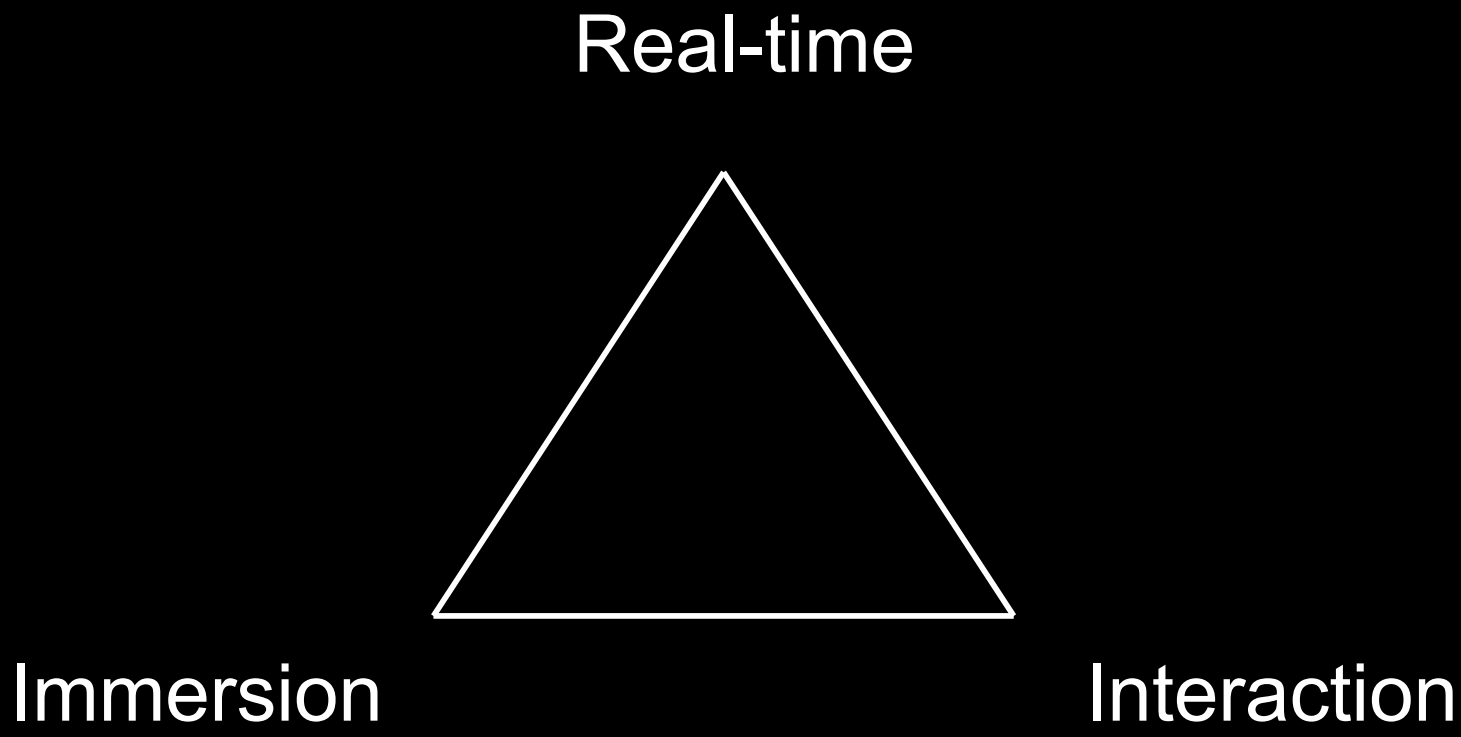
1982

2009

Avatar (2009)



The virtual reality triangle



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

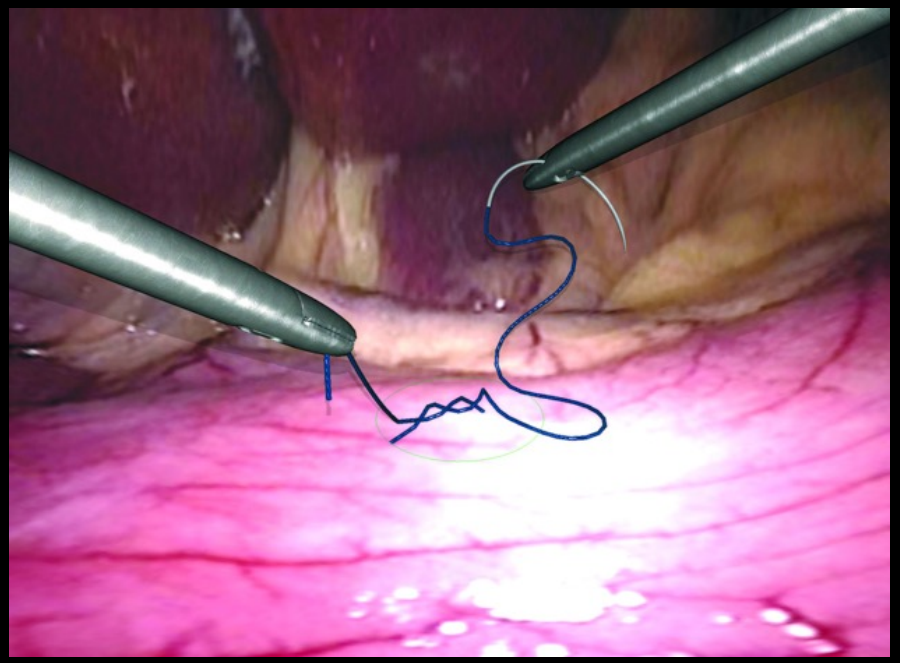
Interaction

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

World of Warcraft

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

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.

Head-mounted displays

Playstation VR (Sony)

Oculus Rift (Facebook)

Head-mounted displays

HTC Vive (HTC and Valve)

Google Cardboard (Google)

Requirements for virtual reality

- 3D stereoscopic display

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

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

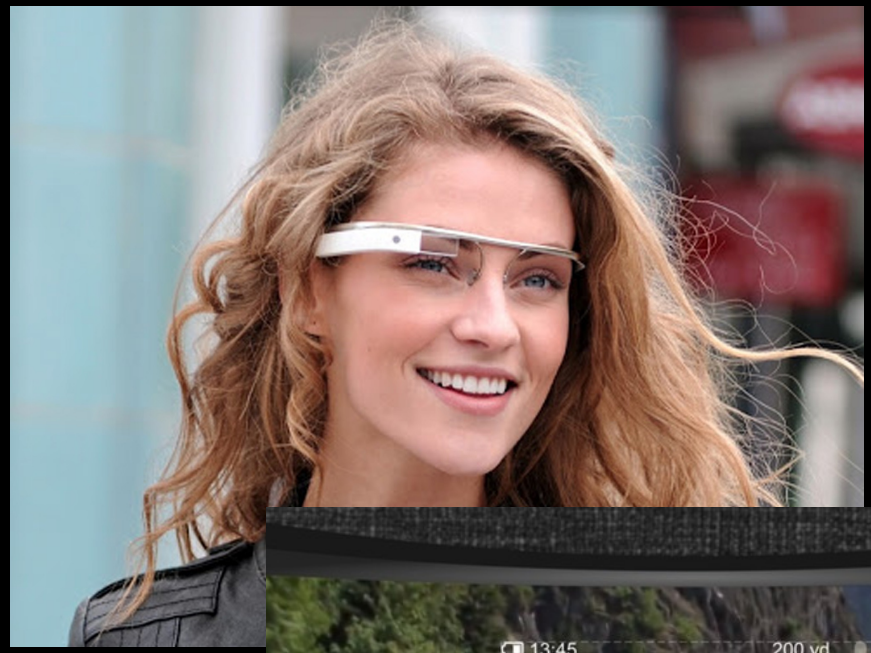
Cave

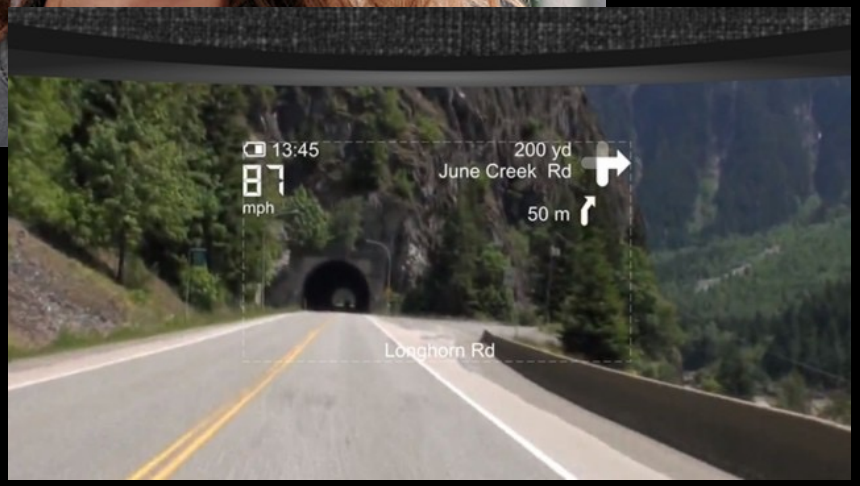
- Project 3D CG into a cube with displays surrounding the viewer
- Coupled with head tracking systems (and other tracking systems e.g. hand)
- Usually surround audio feedback
- Viewer explores virtual world by moving and interacting in the virtual environment

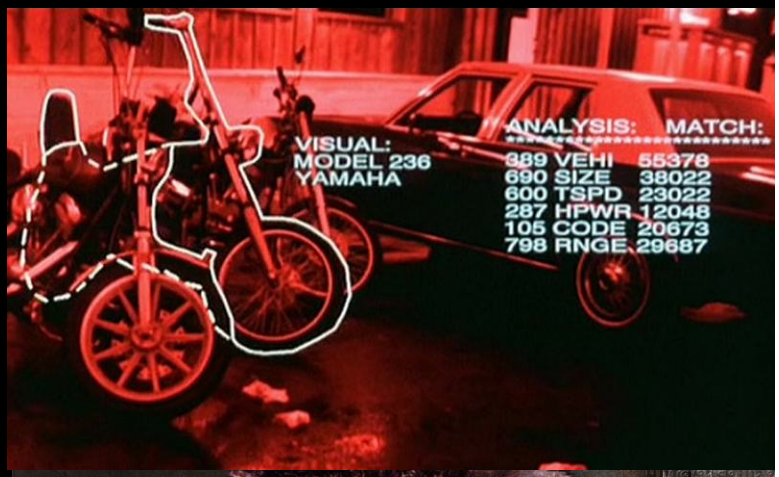
Source: Dave Pape

Augmented reality

- Enhances your reality with graphics, haptics, sound







Source: bestofmicro.com, cultofandroid.com

Augmented reality headsets

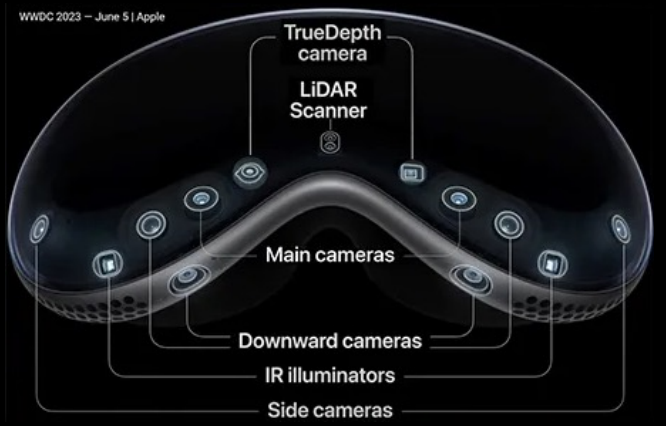
HoloLens (Microsoft) (2016)
Hololens 2 (2019)

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

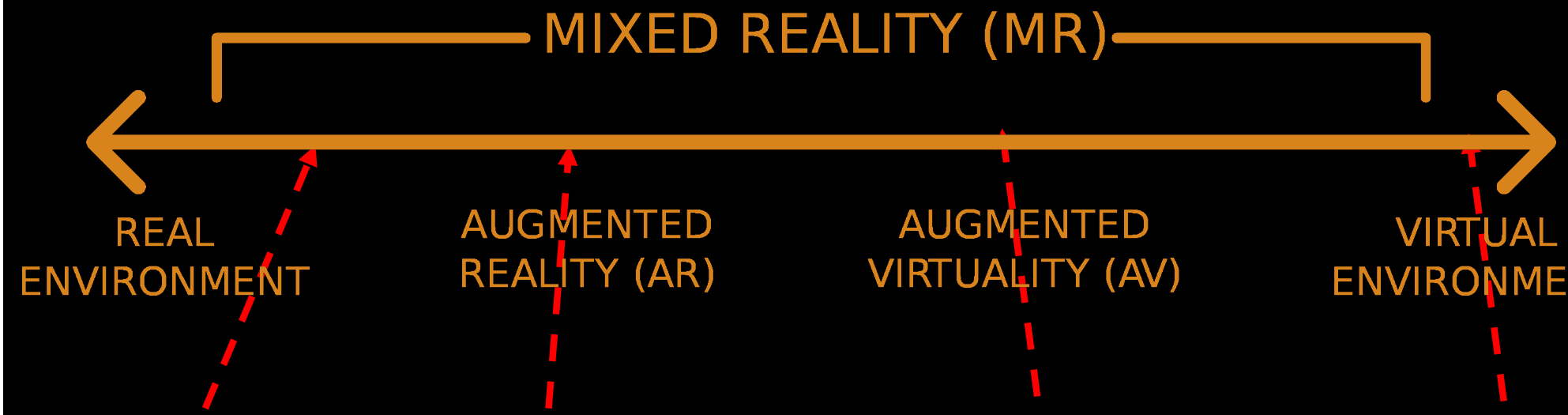
Augmented reality headsets

Apple Vision Pro (2024)

Pass-through technology



The different realities



Pokemon Go

Microsoft Hololens

green screen for weather reporting

Source: https://scripted.video

Sony Playstation VR

virtual environment with real objects

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

Virtual reality “hardware”

Source: Dave Pape (VPL Research; Jaron Lanier)

Source: Mario Tama, Getty Images

Source: VirtuSphere

HoloTile (Disney Imagineering, 2024)

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

Source:
LA Times

Flight simulators

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

Source: NASA

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

Train simulation

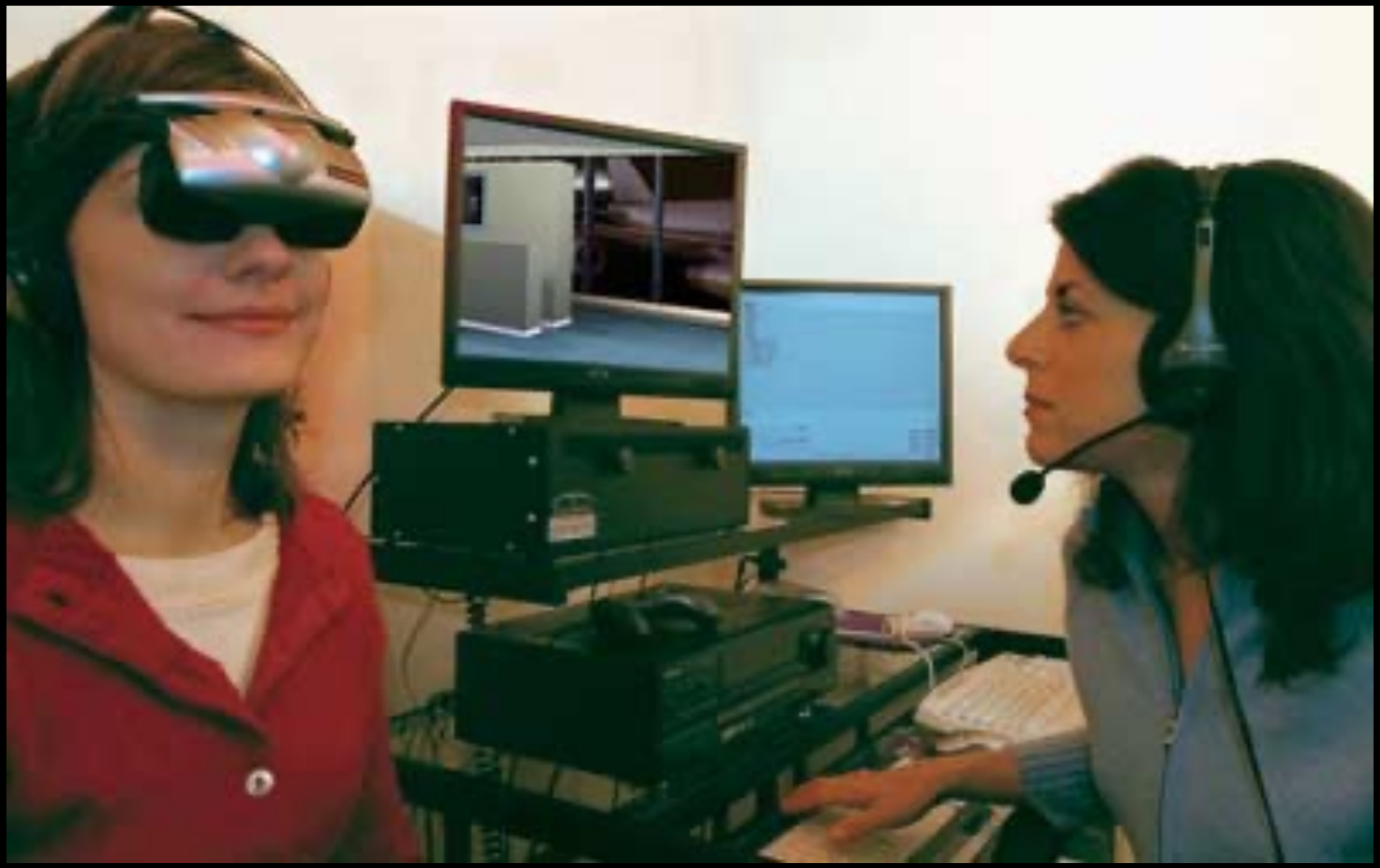
Fujitsu train simulator (2008)

Tank simulator

Stryker armored vehicle simulator

Source: Jason Kaye, U.S. Army

Application in medicine: Phobia treatment



Source: Virtually Better, Inc.

Application in medicine: Phobia treatment

Source: Virtually Better, Inc.

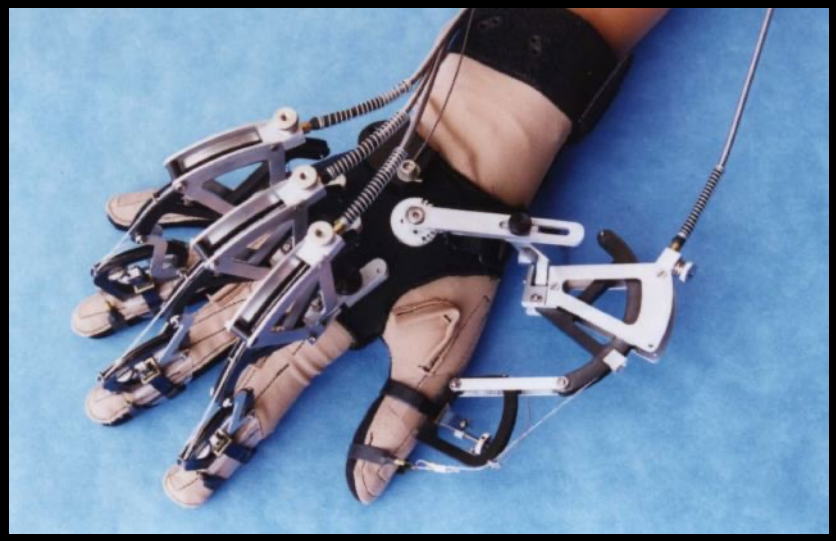
Application in TV and sports

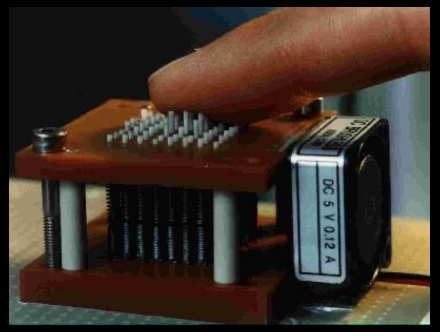
First-down line

Source: SporTVision

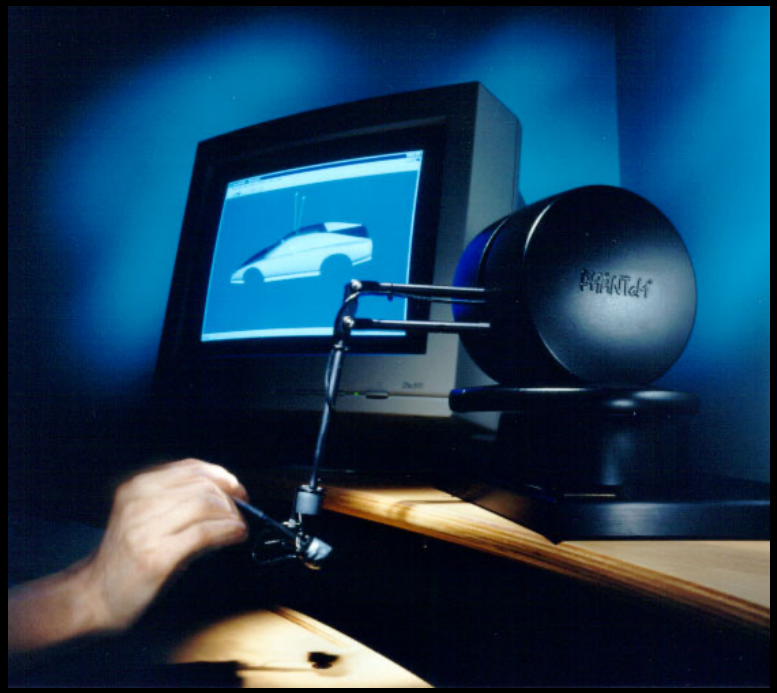
Haptic interfaces

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





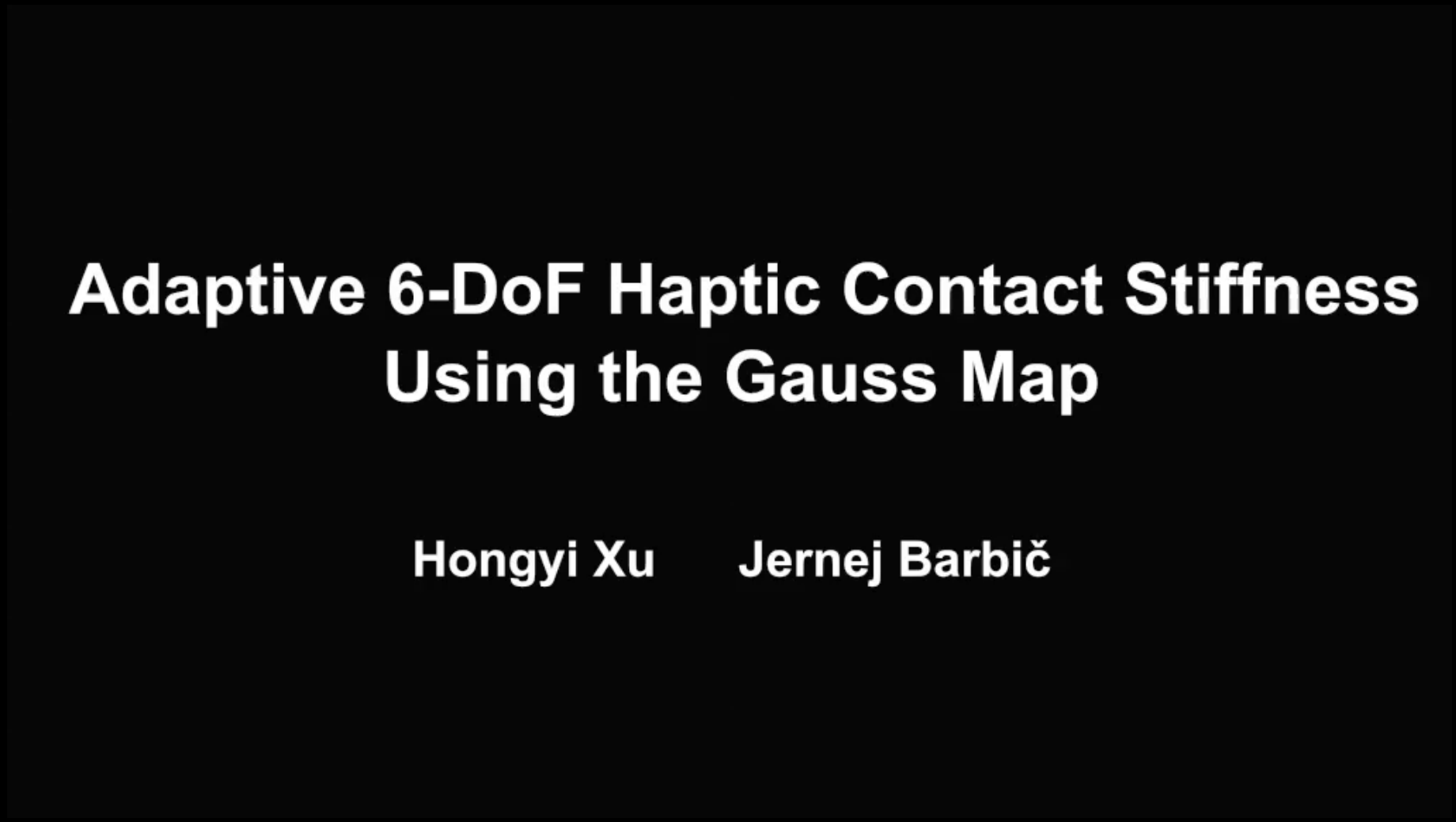
Force-feedback rendering



Phantom 3-DoF device
(Sensable)

Force-feedback
mouse
(Immersion)

Force-feedback rendering



Xu and Barbic 2016

Simulation in games

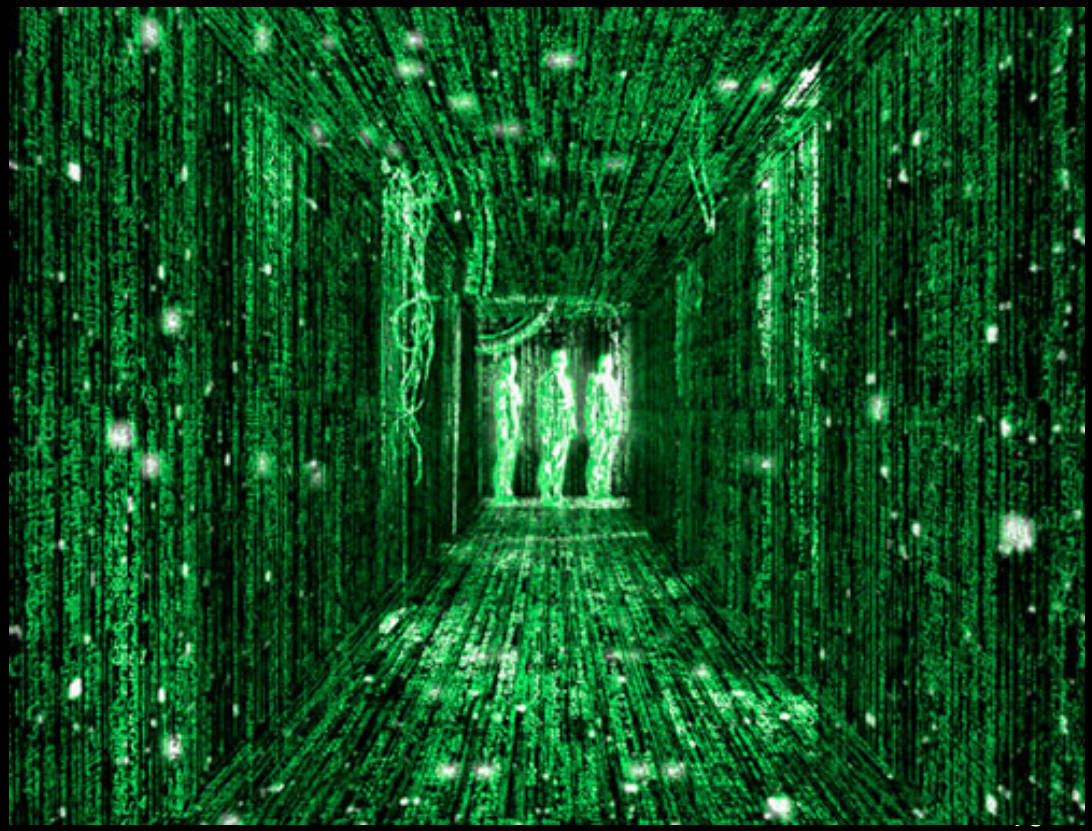
Silent Hunter 4 (Ubisoft)

Virtual reality in games

Source: Colin Anderson

Discussion

- Can we simulate anything?
- What is reality?



Why virtual worlds?

Leontopodium alpinum

Source: appolonio&battista