

# 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

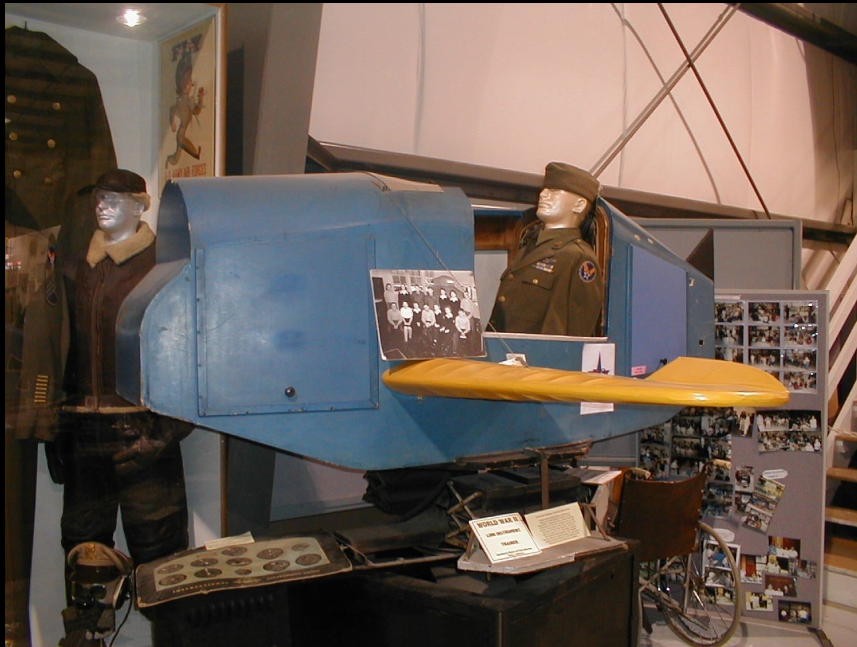


# 14 grand challenges in engineering (by the US National Academy of Engineering)

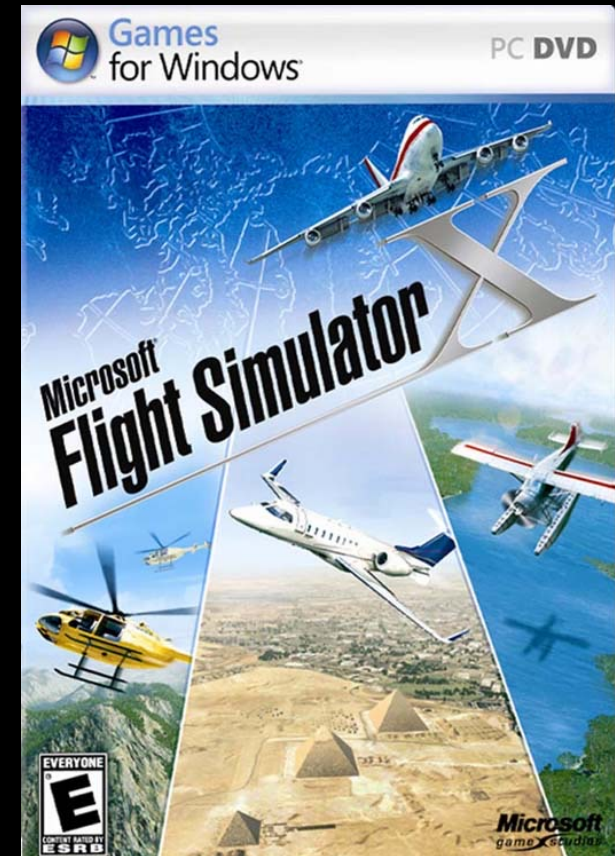
- Make Solar Energy Economical
- Provide Energy from Fusion
- Develop Carbon Sequestration Methods
- Manage the Nitrogen Cycle
- Provide Access to Clean Water
- Restore and Improve Urban Infrastructure
- Advance Health Informatics
- Engineer Better Medicines
- Reverse-Engineer the Brain
- Prevent Nuclear 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

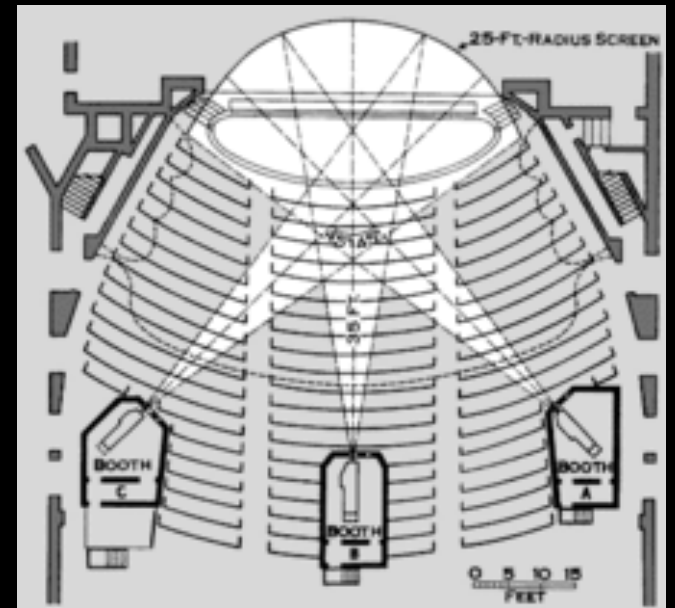
# Cinerama

- 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



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

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

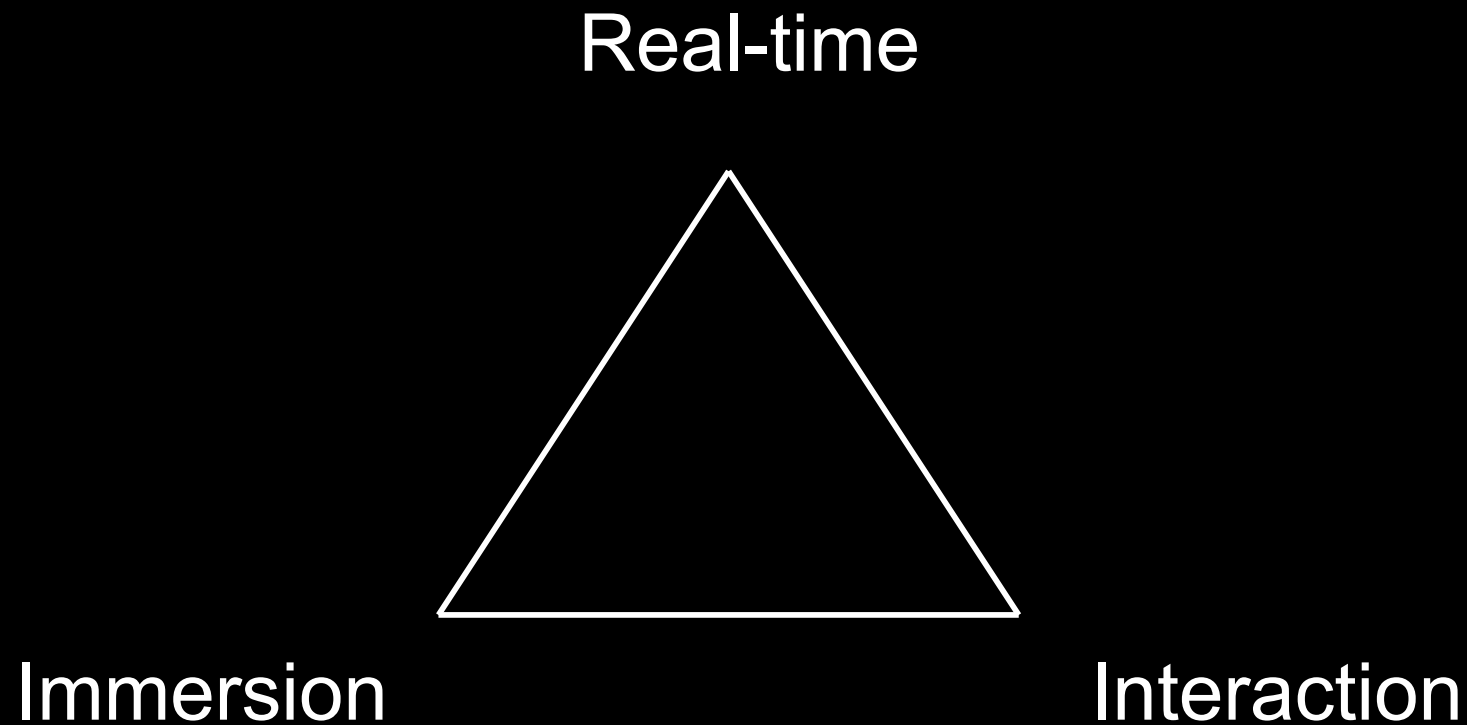


# Avatar (2009)





# 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

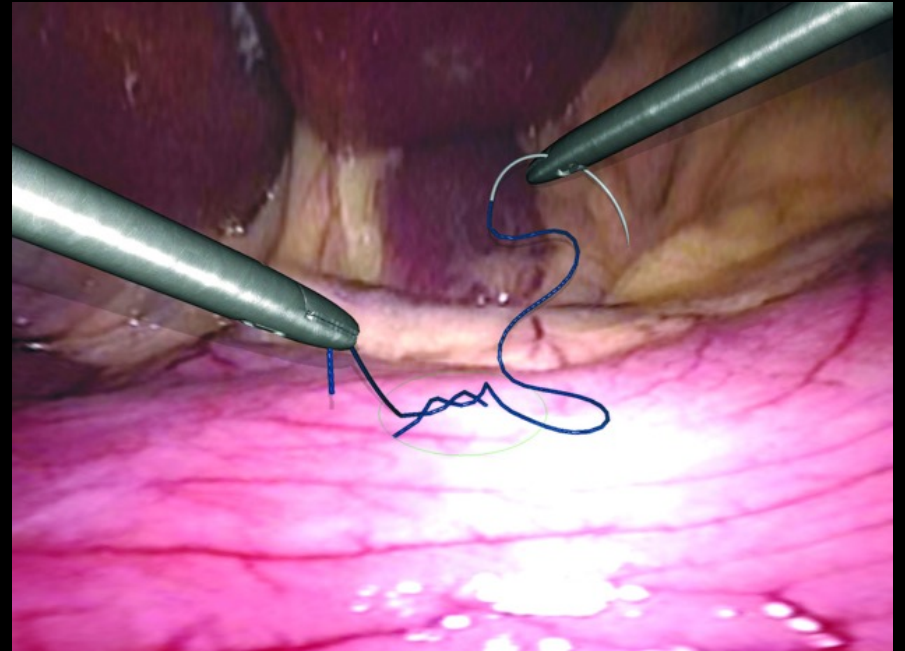
- Possibility of moving in the virtual space and manipulate objects
- Without it, illusion breaks down quickly



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

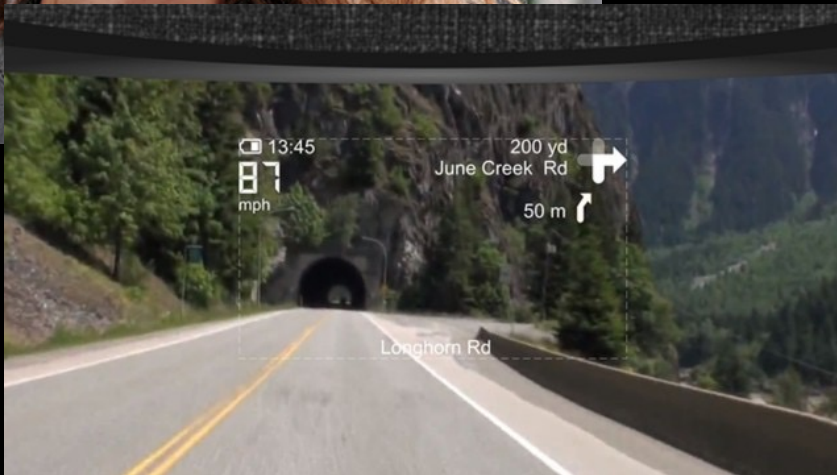


Source: Dave Pape



# Augmented reality

- Enhances your reality with graphics, haptics, sound



Source: [bestofmicro.com](http://bestofmicro.com),  
[cultofandroid.com](http://cultofandroid.com)

# Augmented reality headsets



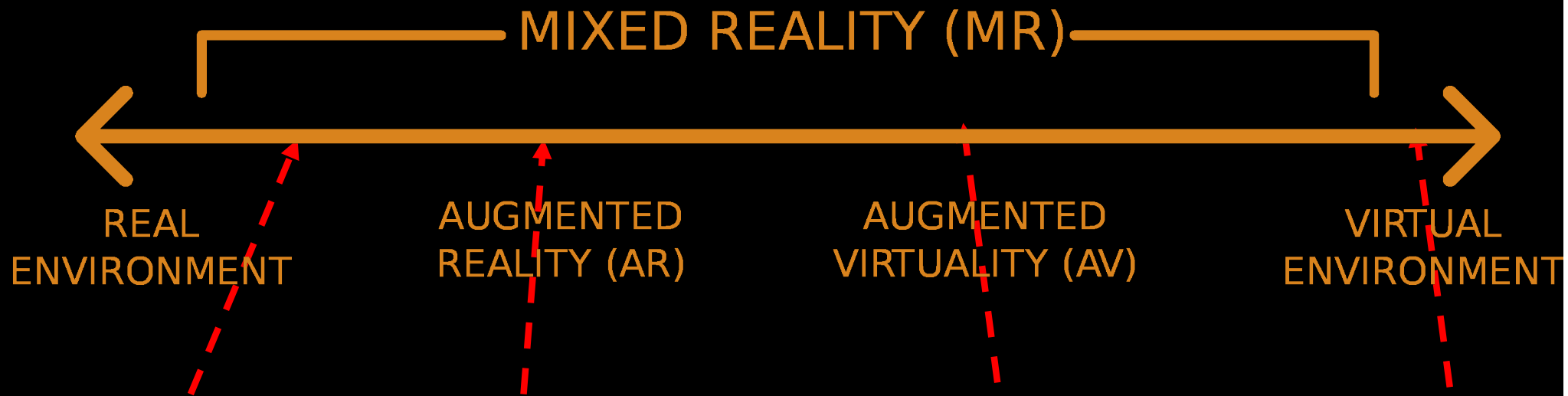
Microsoft HoloLens (Microsoft);  
released Hololens 2 in Feb 2019



Magic Leap One (Aug 2018)  
(Magic Leap)



# The different realities



Pokemon Go



Microsoft Hololens



green screen for weather reporting

Source: <https://scripted.video>



Sony Playstation VR

# 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

# 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)





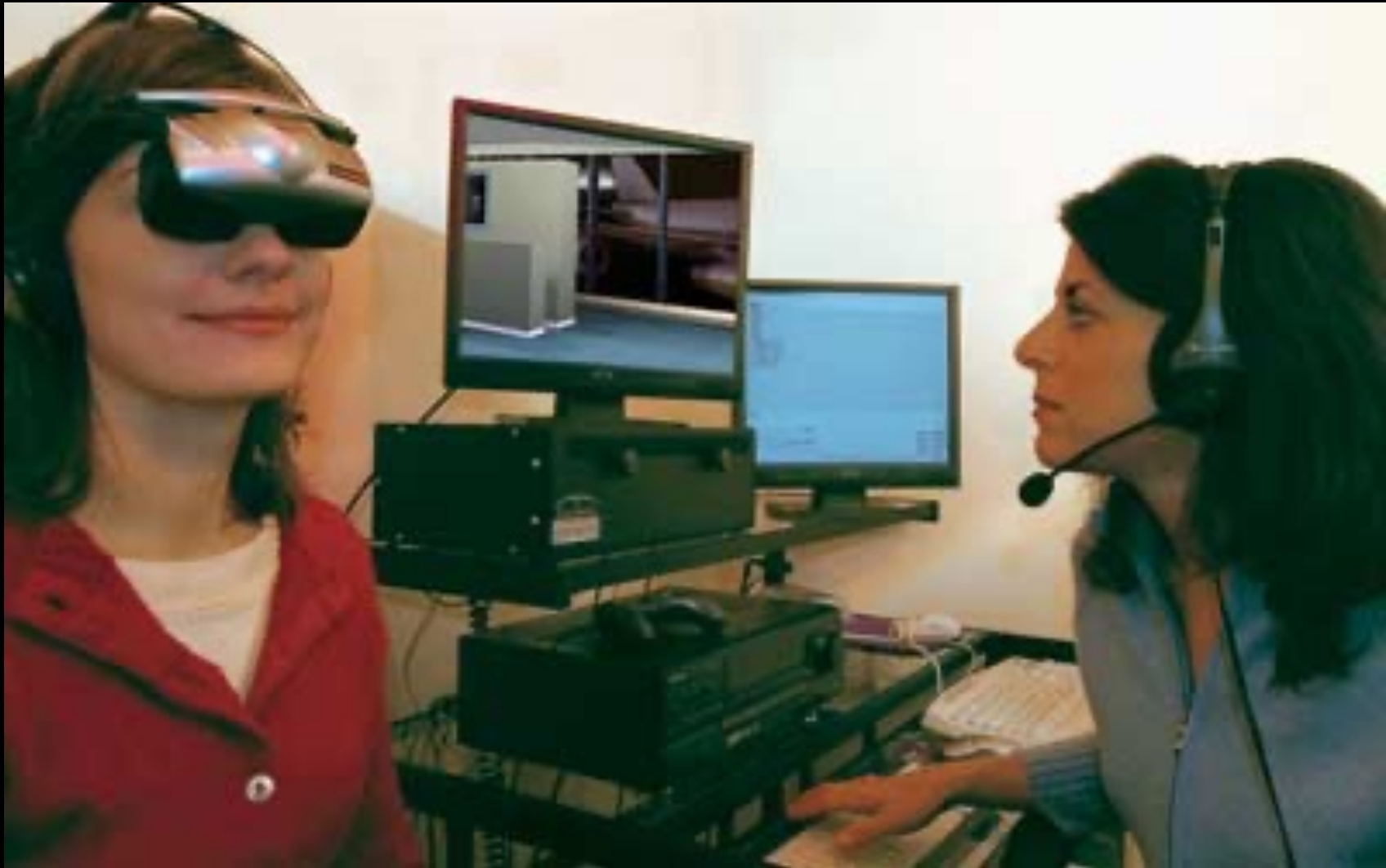
# Tank simulator



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



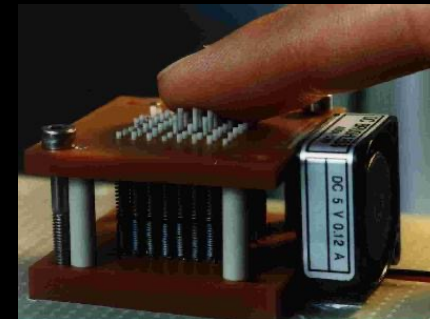
First-down line

Source: SporTVision



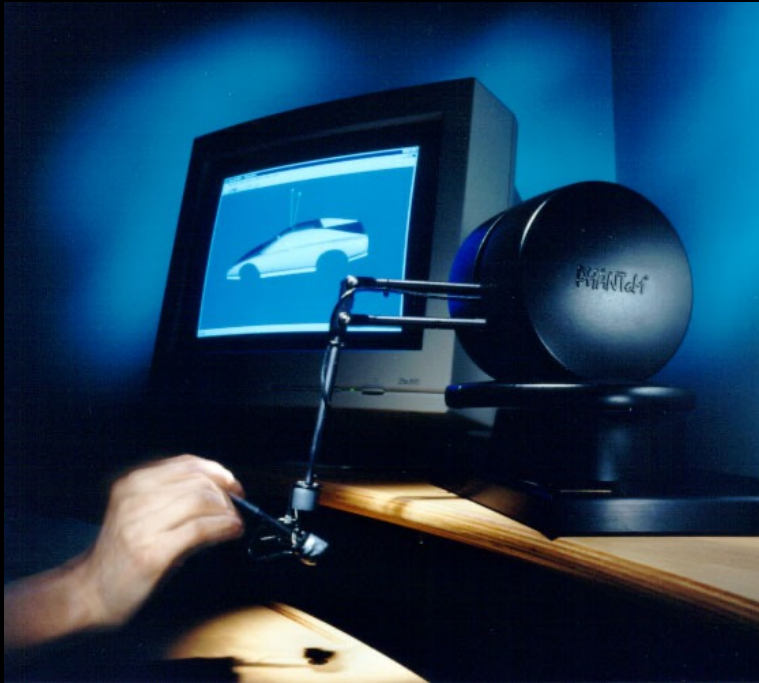
# Haptic interfaces

- 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

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

**Hongyi Xu    Jernej Barbič**

Xu and Barbic 2016

# Simulation in games



Silent Hunter 4 (Ubisoft)

# Virtual reality in games

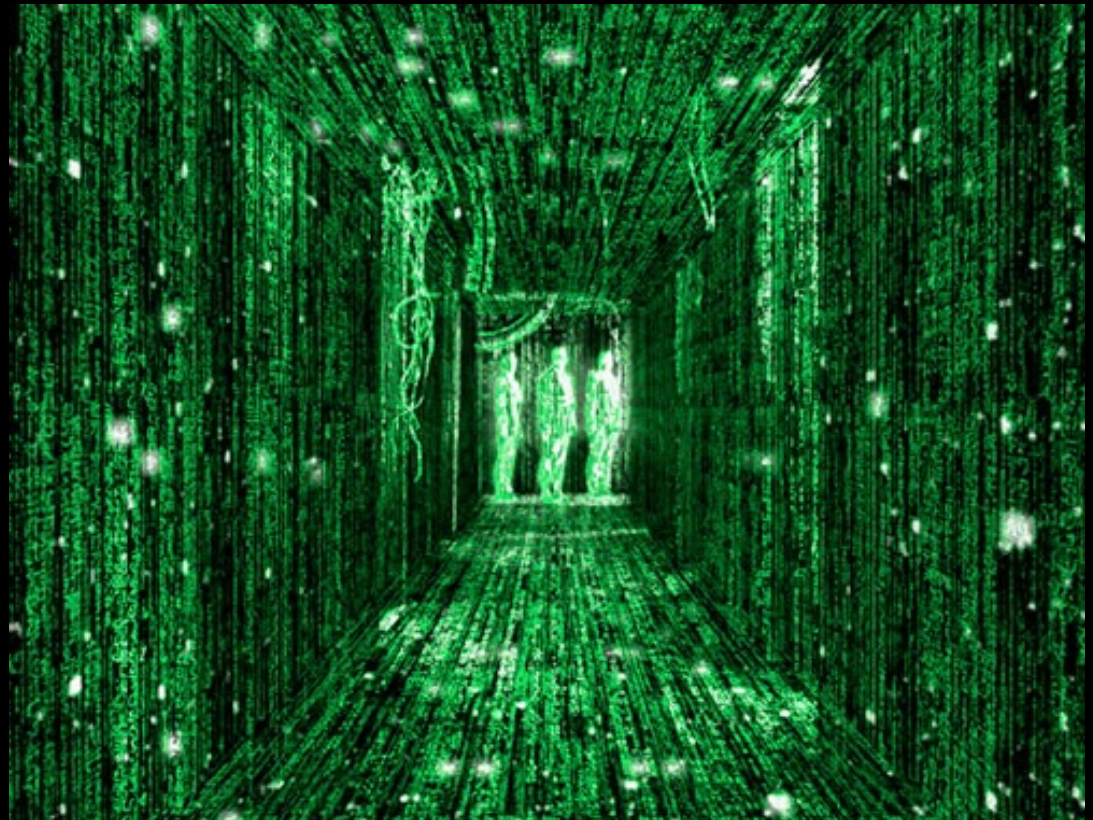


Source: Colin Anderson



# Discussion

- Can we simulate anything?
- What is reality?



# Why virtual worlds?



*Leontopodium alpinum*

Source: appolonio&battista