Virtual Reality

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

Jernej Barbic
University of Southern California

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

Source: NASA

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


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

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

Virtual reality and film

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

The virtual reality triangle

- Real-time
- Immersion
- Interaction

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

**Real-time**

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

**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**

**Head-mounted displays**

- Oculus Rift (Facebook)
- HTC Vive (HTC and Valve)
- Google Cardboard (Google)

**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

**Augmented reality**

- Enhances your reality with graphics, haptics, sound

Source: Surgical Science

Source: Atticus Graybill of Virtually Better, Inc.

Source: Dave Pape

Source: bestofmicro.com, cultofandroid.com
Augmented reality headsets

Microsoft HoloLens (Microsoft)

Magic Leap (Magic Leap, Google)

Virtual reality “hardware”

Source: Dave Pape

Source: Mario Tama, Getty Images

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 $)


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 TV and sports

First-down line
Source: SporTVision

Haptic interfaces

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

Force-feedback rendering

Phantom 3-DoF device (Sensible)

Force-feedback mouse (Immersion)

Barbič and James 2007
**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: appoloniabattista