Virtual Reality

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

Jernej Barbic
University of Southern California
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
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
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

Cinerama

How the west was won, 1962 (John Ford)
Virtual reality and film

• VR heavily influenced by film techniques

• Hollywood, from early 1950s

1982

TRON

2009

AVATAR
Avatar (2009)
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

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**
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
Virtual reality “hardware”

Source: Dave Pape

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
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 (Sensible)

Force-feedback mouse (Immersion)
Force-feedback rendering

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: appolonio&battista