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

Occulus 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
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

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

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

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

Magic Leap One (Aug 2018) (Magic Leap)
The different realities

MIXED REALITY (MR)

REAL ENVIRONMENT

AUGMENTED REALITY (AR)

AUGMENTED VIRTUALITY (AV)

VIRTUAL ENVIRONMENT

Pokemon Go

Microsoft Hololens

green screen for weather reporting

Sony Playstation VR

Source: https://scripted.video
# Virtual Reality vs Augmented Reality

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<th></th>
<th>Virtual Reality</th>
<th>Augmented Reality</th>
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<tr>
<td><strong>Modeling complexity</strong></td>
<td>Requires high-resolution models</td>
<td>Not so demanding as VR</td>
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<tr>
<td><strong>Display technology</strong></td>
<td>Wide field of view</td>
<td>Can be narrow field of view</td>
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<tr>
<td><strong>Tracking</strong></td>
<td>Not as demanding as AR</td>
<td>Must be high-quality</td>
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Virtual reality “hardware”

Source: Dave Pape (VPL Research; Jaron Lanier)

Source: VirtuSphere

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 $)

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

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