Introduction to Virtual Reality

CS 6334 Virtual Reality
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The University of Texas at Dallas

Some slides of this lecture are based on the Virtual Reality textbook by Steven LaValle
Who am I?

• Assistant Professor in CS at UTD (joined Fall 2021)
  • Research area: robotics and computer vision
• Senior Research Scientist at NVIDIA (2018 – 2021) Robotics
• Postdoc Stanford, University of Washington (2016 – 2018)
• Ph.D., Electrical and Computer Engineering, University of Michigan, 2016
• Master, CS, Fudan University, China, 2010
• Bachelor, CS, Fudan University, China, 2007
Introduce yourself

• Name

• Major program

• Which year in the program?

• Where are you from?
What is Virtual Reality?

Birdy experience from the Zurich University of the Arts
What is Virtual Reality?

(a) An experimental setup used by neurobiologists at LMU Munich to present visual stimuli to a gerbil while it runs on a spherical ball that acts as a treadmill.

(b) A picture of a similar experiment, Princeton University
Definition of Virtual Reality

• “Inducing targeted behavior in an organism by using artificial sensory stimulation, while the organism has little or no awareness of the interface” – Steven LaValle

  • Targeted behavior: designed by the creator, flying, walking, exploring, gaming

  • Organism: humans, animals, fruit fly, fish, etc.

  • Artificial sensory stimulation: vision, audio, touch, etc.

  • Unawareness: unawareness of the interface, being “fooled” in a virtual world
What is Virtual Reality?

Target behavior: flying
Organism: the user
Artificial sensory stimulation: vision, wind, body motion
Unawareness: feels like in the air of San Francisco

Birdy experience from the Zurich University of the Arts
More VR Examples

- Training
- Gaming
- Education
- Control
- Visualization
- Socializing
Augmented Reality

- Visual stimuli are from both the virtual world and the real world

  - Combines real and virtual

  - Interactive in real time

  - Registered in 3D

  - Unawareness

Microsoft HoloLens
More AR Examples

Gaming

Shopping

Assisting

Navigation

Training

Surgery
National Academy of Engineering

• “Enhance Virtual Reality” is 1 of 14 NAE grand challenges for engineering in the 21st century
A Brief History of Virtual Reality

- **1838**: Stereoscope invented by Charles Wheatstone.
- **1957**: Sensorama developed by Morton Heilig.
- **1968**: Head-Mounted Display created by Ivan Sutherland.
- **1992**: Cave Automatic Virtual Environment introduced by Ivan Sutherland.
- **1995**: Nintendo Virtual Boy released.
- **2016**: Oculus Rift introduced.
Stereoscopes since 1838

• Humans perceive depth and 3D from stereopsis

• A stereoscope displays images for left-eye and right eye

Charles Wheatstone, 1838

Holmes stereoscope, 1861

View-Master, 1930s
Sensorama by Morton Heilig (1957)

- 3D motion picture through stereoscopic display
- Pre-recorded video content
- Stereo sound
- Smell
- Wind
- Seat vibrations
First Head-Tracker  Head-Mounted Display (1968)

- Ivan Sutherland developed the first head-tracked, head-mounted display
  - Tracked head movements
  - Perception of stationary

Computer scientist
VPL Research (company) by Jaron Lanier (1984)

• The DataGlove
  • Wired to computer
  • Track hand movements and orientations
  • Allow people to manipulate and re-orient virtual objects

• The EyePhone
  • An HMD to immerse users into a computer simulation
  • Track head movement

• The DataSuit
  • A full-body outfit with sensors for measuring the movement of arms, legs and trunk
Cave Automatic Virtual Environment (1992)

• A room with video projected on walls

• Stereoscopic viewing using polarized light and special glasses

• Head tracking for viewpoint-dependent video
Nintendo Virtual Boy (1995)

• 32-bit portable video game console with HDM

• Marketed as the first console capable of displaying stereoscopic 3D graphics

• Sales failed to meet targets, and Nintendo ceased distribution in 1996
  • Released 22 games for the system
Revival of VR (2016)

Oculus Rift

HTC Vive

Playstation VR

Tracking technologies
Overview of VR Systems

Tracking
- Head tracking
- Eye tracking
- Button presses
- Controller movements
- User interactions

Stimulation
- Vision
- Audio
- Haptics
- Track Objects
- Robotic interface

Organism

VR Hardware

Surrounding Physical World
Natural V.S. Virtual

Natural Stimulation → Sense Organ → Neural Pathways

Virtual World Generator → Display → Sense Organ → Neural Pathways
VR Systems

**INPUT**
- Head Tracker
- Game Controller
- Keyboard & Mouse

**COMPUTATION**
- Virtual World Generator

**OUTPUT**
- Visual Renderer
- Aural Renderer
- Haptic Renderer

- Visual Display
- Aural Display
- Haptic Display
What will you learn in this course?

• Ability to develop 3D virtual environments
• Ability to render 3D virtual worlds into images
• Ability to understand human visual system and visual perception
• Ability to understand audio and haptics
• Ability to develop head tracking, eye tracking and pose tracking techniques
• Ability to develop locomotion, 3D selection and manipulation techniques
• Ability to develop robotic interfaces
Grading Policy

• Homework (40%)
  • 4 homework in total
  • Individual submission

• Team Project (55%): prototype of a VR system
  • 2 or 3 students for a project
  • Project proposal (5%)
  • Project mid-term report (10%)
  • Project presentation (15%)
  • Project final report (25%)

• In-class Activity (5%)

• No final exam!
Course Details

• Textbook

• My office hour
  Monday & Wednesday 2:30PM – 3:30 PM
  Email Appointment

• TA office hour: TBD

• Course access and navigation: eLearning