What is this course about?

- Fundamentals of AR/VR:
  - Hardware and Technology.
  - Perception.
  - Interaction techniques.
  - Applications.
- Read and present AR/VR papers.
- Build an AR/VR project.
- Evaluation:
  - Creative experiment/prototype 25%.
  - Technical Paper presentation 25%.
  - Project (2-3 people working together) 50% (mid-term evaluation 10%, report 10%).
What is Virtual Reality?

**virtual reality**  
*noun*

**Simple Definition of VIRTUAL REALITY**

: an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it

Source: Merriam-Webster's Learner's Dictionary

...an interactive computer-generated experience taking place within a simulated environment, that incorporates mainly auditory and visual, but also other types of sensory feedback like haptic.  
*Wikipedia*
Holodeck (Star Trek: The Animated Series 1974)
The Ultimate Display

“The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.”

Ivan Sutherland, 1965
Making Interfaces Invisible

David Zeltzer’s AIP Cube

- **Autonomy** – User can react to events and stimuli.
- **Interaction** – User can interact with objects and environment.
- **Presence** – User feels immersed through sensory input and output channels.

Augmented Reality

- Combines Real and Virtual Images registered in 3D.
- Interactive in real-time for virtual content.

1977 – Star Wars

Pokemon GO..
## AR vs. VR

<table>
<thead>
<tr>
<th></th>
<th>Virtual Reality</th>
<th>Augmented Reality</th>
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<tbody>
<tr>
<td><strong>Scene Generation</strong></td>
<td>Requires realistic images</td>
<td>Minimal rendering okay</td>
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<tr>
<td><strong>Display Device</strong></td>
<td>Fully immersive, wide field of view</td>
<td>Non-immersive, small field of view</td>
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<tr>
<td><strong>Tracking</strong></td>
<td>Low to medium accuracy is okay</td>
<td>The highest accuracy possible</td>
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Milgram’s Reality-Virtuality continuum

"...anywhere between the extrema of the virtuality continuum."

Mixed Reality

Real Environment Augmented Reality (AR) Augmented Virtuality (AV) Virtual Environment

Reality - Virtuality (RV) Continuum

P. Milgram and A. F. Kishino, Taxonomy of Mixed Reality Visual Displays
When anything new comes along, everyone, like a child discovering the world thinks that they’ve invented it, but you scratch a little and you find a caveman scratching on a wall is creating virtual reality in a sense.

Morton Helig (Hammit 1993)
Early History (30,000 BC - )

The history of VR is rooted in human’s first attempts to reproduce the world around them.
1800’s – Capturing Reality

- Panoramas (1790s)
  - Immersive paintings
- Photography (1820-30s)
  - Oldest surviving photo (Niépce, 1826)
- Stereo imagery (1830s)
  - Wheatstone (1832)
  - Brewster (1851)
- Movies (1870s)
  - Muybridge (1878)
  - Roundhay Garden Scene (1888)
Viewmaster (1939)
3D Cinema Golden Era (1950-60s)

- Polarized 3D projection or anaglyph (red/blue)
Link Trainer (1929 – 1950s)

- Flight Simulator Training
  - Full six degree of freedom rotation
  - Force feedback and motion control
  - Simulated instruments
  - Modeling common flight conditions
- Over 500,000 pilots trained
Link Trainer Video (1966)

https://www.youtube.com/watch?v=MEKkVg9NqGM
Sensorama (1955)

- Created by Morton Heilig
- Experience Theater
- Multi-sensory
  - Visuals
  - Sound
  - Wind
  - Vibration
  - Smell
- No financial support
  - Commercial failure
Sensorama Video

https://www.youtube.com/watch?v=vSINEBZNcks
The Data Glove (1981-82)

- Precursor, Sayre Glove
  - Univ. of Illinois, 1977
- Thomas Zimmerman (1982)
- Fiber optic bend sensors
  - Detecting finger bending
- Commercialized by VPL
  - Mattel PowerGlove (1989)
CAVE (1992)

- Projection VR system
  - 3-6 wall stereo projection, viewpoint tracking
  - Developed at EVL, University of Illinois Chicago
- Commercialized by Mechdyne Corporation (1996)

CAVE Demo Video

https://www.youtube.com/watch?v=aKL0urEdtPU
Desktop VR - 1995

- Expensive - $150,000+
- 2 million polys/sec
- VGA HMD – 30 Hz
- Magnetic tracking
Virtual Reality was HOT! .. In 1995..
Don't Believe the Hype: The 21 Biggest Technology Flops

We fondly recall 21 overpromoted products and technologies that utterly failed to live up to their hype -- and we give you a chance to choose the biggest flop of all.

David Haskin  Today's Top Stories  or  Other Hardware Stories

April 2007 Computer World

VR Voted 7th on list of 21 biggest technology flops
VR Second Wave (2010 - )

- Palmer Luckey
  - HMD hacker
  - Mixed Reality Lab (MxR) intern

- Oculus Rift (2011 - )
  - 2012 - $2.4 million kickstarter
  - 2014 - $2B acquisition FaceBook
  - $350 USD, 110° FOV
The Oculus Kickstarter Video

https://www.youtube.com/watch?v=aNSYscbxFAw
HTC Vive

- Room scale tracking
- Gesture input devices
Google Cardboard

- Released 2014 (Google 20% project)
- >5 million shipped/given away
- Easy to use developer tools
Multiple Mobile VR Viewers Available
Augmented Reality

1977 – Star Wars
Pepper’s Ghost (1862)

• Dates back to Giambattista della Porta (1584)
"It consists of this pair of spectacles. While you wear them every one you meet will be marked upon the forehead with a letter indicating his or her character. The good will bear the letter 'G,' the evil the letter 'E.' ... Thus you may determine by a single look the true natures of all those you encounter."

L. Frank Baum
Early HUD (1958)

F16 – Head Up Display
Development of the Field

- 1996: MIT Wearable Computing efforts
- 1998: Dedicated conferences begin (ISMAR)
- Late 90’s: Collaboration, outdoor, interaction
- Late 90’s: Augmented sports broadcasts
Google Glass (2011 - )
Hololens (2016)

- Integrated system – Windows
- Stereo see-through display
- Depth sensing tracking
- Voice and gesture interaction
View Through Hololens

- https://www.youtube.com/watch?v=RddvMLwT__g
Strong vs. Weak AR

- Weak AR
  - Imprecise tracking
  - No knowledge of environment
  - Limited interactivity
  - Handheld AR

- Strong AR
  - Very accurate tracking
  - Seamless integration into real world
  - Natural interaction
  - Head mounted AR
Summary

• AR/VR technology can be used to develop a wide range of applications

• Promising application areas include
  • Games
  • Education
  • Engineering
  • Medicine
  • Museums
  • Real Estate
  • Etc..