

LECTURE 1: COURSE OVERVIEW

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<http://web.cecs.pdx.edu/~aryafare/VR.html>

Introductions

- Who am I?
 - Joined PSU in 2017
 - Worked at Intel Labs in Santa Clara from 2013-2017 on 5G/5G+
 - Rice PhD 2011 and 2 years of PostDoc at Princeton University
 - Research in “computer and information science and engineering”
- Some statistics about you
 - 60% of class is undergraduate
 - 40% of class is graduate (mix of Master’s and PhD students)
- Single Teaching Assistant to Help with Unity Labs
 - Samuel Shippey

Outline

- Intro to virtual reality
- VR status quo (and how we got here!)
- What this course is about
- Course structure and logistics

Virtual Reality

- What is virtual reality?
- How many of you have experimented with VR?
- How many of you have access to VR hardware?

Virtual Reality

- The computer-generated simulation of a 3D image or environment that can be interacted with in a seemingly real way. Person in the VR world **perhaps** needs to use special electronic equipment



Existing Virtual Reality Systems

- Standard VR systems use **VR headsets** or **multi-projected environments** to generate realistic **images**, **sounds**, or **other sensations** that simulate a user's presence in a VR environment!
 - VR headsets use a head mount display (HMD) with screens in front of eyes
 - can also use rooms with large screens
- VR typically uses audio and video feedback, but may also allow other sensory (force, vibration) feedback through haptic technology or 3D touch (create an experience of touch)



A 1980 HMD and wired gloves at the NASA Ames

What about other senses?

Fully Immersive VR Experience

- A fully immersive VR experience require complete immersion in the virtual environment
 - High quality video, audio, motion, touch, taste, smell, ...



Omni treadmill
being used at a
VR convention

VR Applications

simulation & training



visualization & entertainment



remote control of vehicles, e.g. drones



gaming



robotic surgery



architecture walkthroughs



education



virtual travel



a trip down the rabbit hole

VR Industry Growth Perspective

- VR technology is on an explosive growth path
- **Consumer VR hardware and software had a market cap of \$6.2 Billion and is expected to be more than \$16 billion in the next three years**
 - **COVID impact on accelerated VR growth and adoption**
- Silicon valley is also heavily investing in VR startups
 - Lots of application beyond the previous slide in healthcare (e.g., anxiety treatment), military, and industry
- All major tech companies (e.g., Facebook, Apple, Amazon, Microsoft, Google) are investing heavily in VR

National Academy of Engineering

“Enhance Virtual Reality” is 1 of 14 NAE grand challenges
in the 21st century



image from NAE

Realm of Reality

- **Virtual reality:** a simulated experience that can be similar or completely different from the real world
- **Augmented reality:** blends what the user sees in their real surroundings with digital content generated by computer software
- **Mixed reality:** merging of real world and virtual worlds to produce new environments where physical and digital objects co-exist and interact in real time.
- **Simulated reality:** is a hypothesis that reality could be simulated in a way indistinguishable from “true” reality.

Engineering Aspects of VR/AR

- cloud computing
- shared experiences



- compression, streaming



- VR cameras



- CPU, GPU
- IPU, DPU?



- sensors & imaging
- computer vision
- scene understanding

- photonics / waveguides
- human perception
- displays: visual, auditory, vestibular, haptic, ...

- HCI
- applications

Where We Are Trying to Go!



Evolution of Computing

Personal Computer
e.g. Commodore PET 1983



Laptop
e.g. Apple MacBook



Smartphone
e.g. Google Pixel



AR/VR
e.g. Microsoft HoloLens

???

A Brief History of Virtual Reality

Stereoscopes
Wheatstone, Brewster, ...



VR & AR
Ivan Sutherland



Nintendo
Virtual Boy



VR explosion
Oculus, Sony, HTC, MS, ...



1838

1968

1995

2012-2020

???

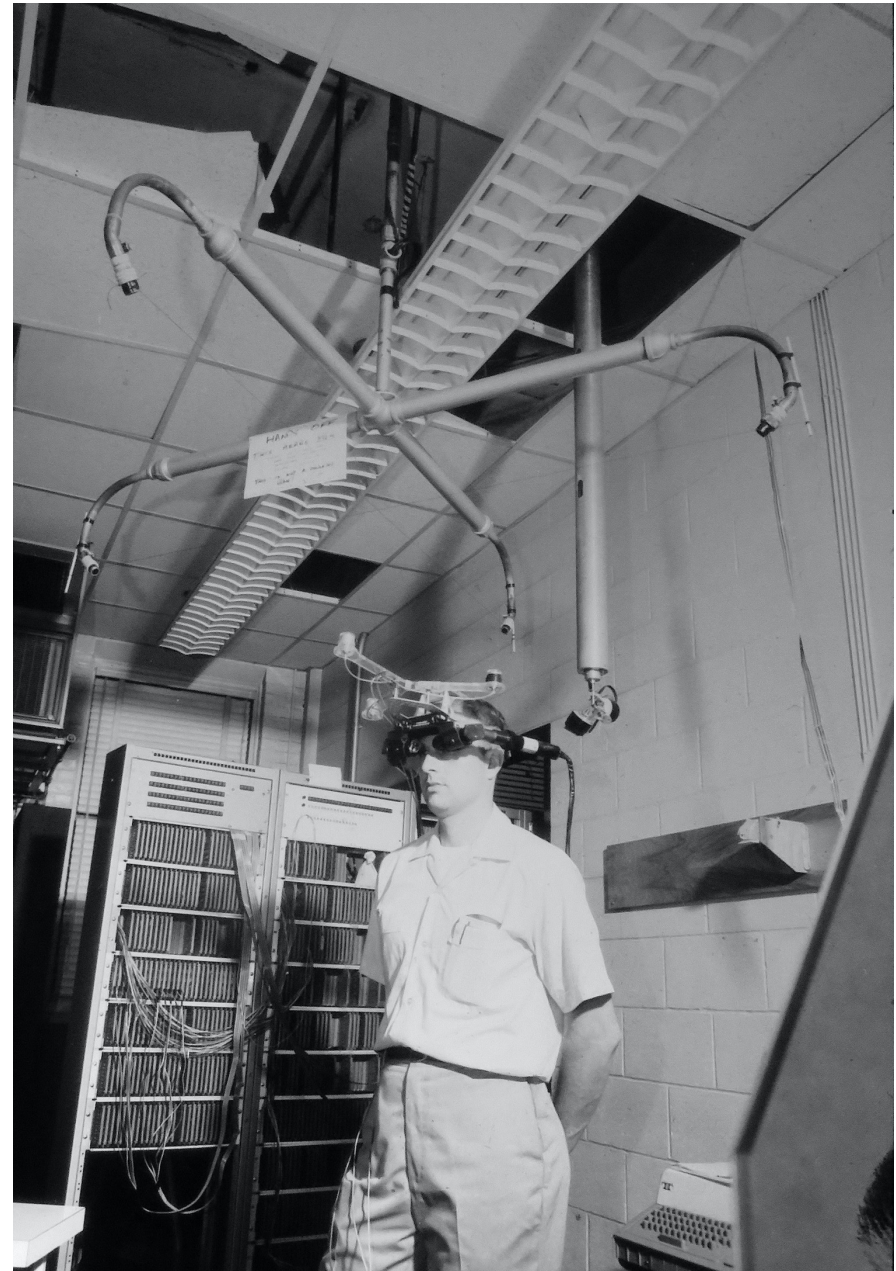
Ivan Sutherland's HMD

- optical see-through AR, including:
 - displays (2x 1" CRTs)
 - rendering
 - head tracking
 - interaction
 - model generation
- computer graphics
- human-computer interaction

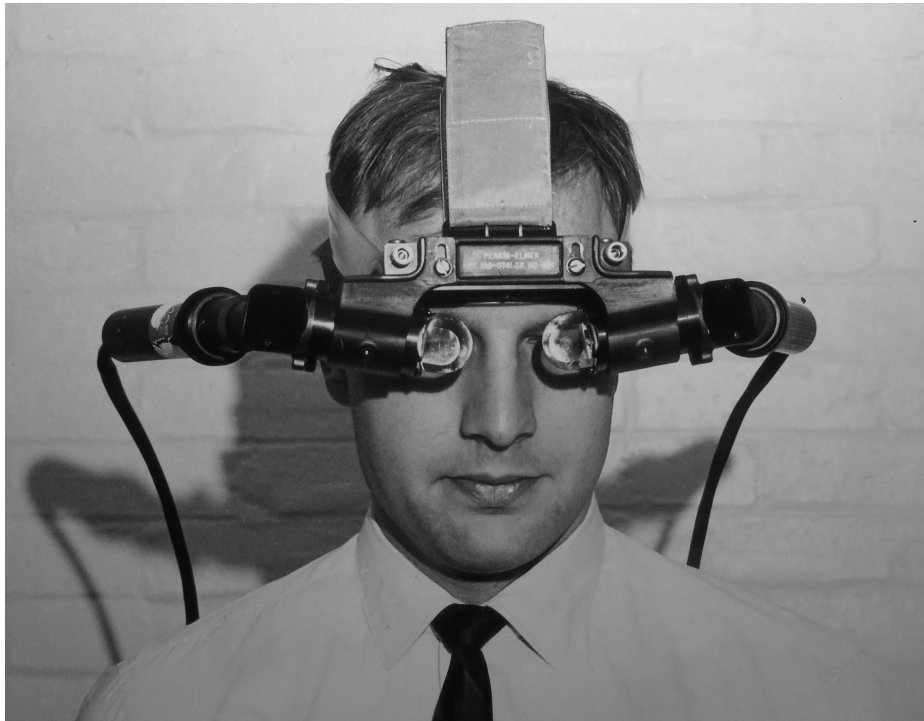
Picture taken in summer 1968

Paper "A head-mounted 3D Display", 1968

The man in picture is not Ivan



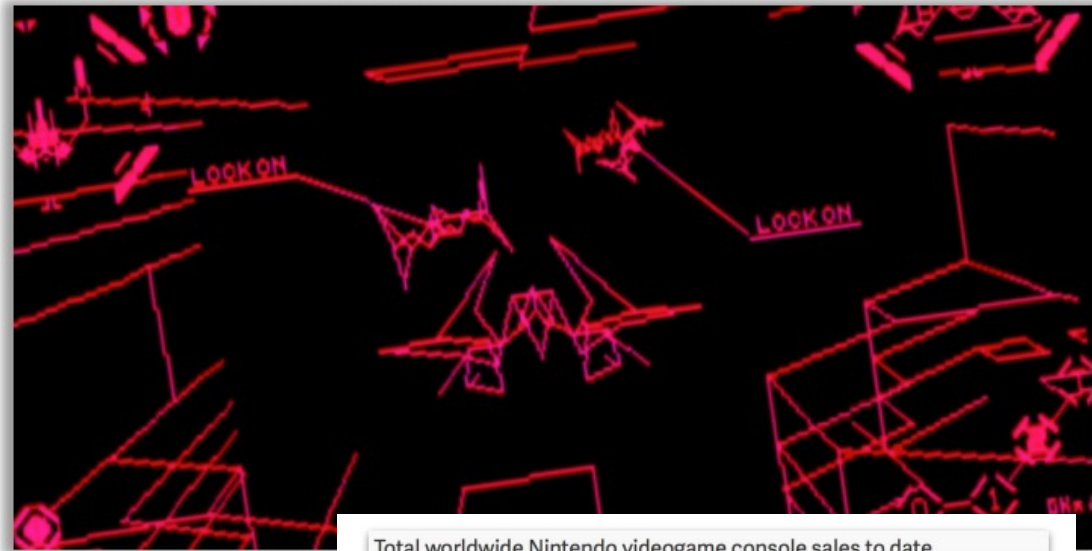
Please note that the sword of Damocles is the mechanical head position sensor, only. Many internet references erroneously apply that catchy name to the whole system. The sword is a big feature (long tube with shaft encoders attached) at the top of the close-up looking up.



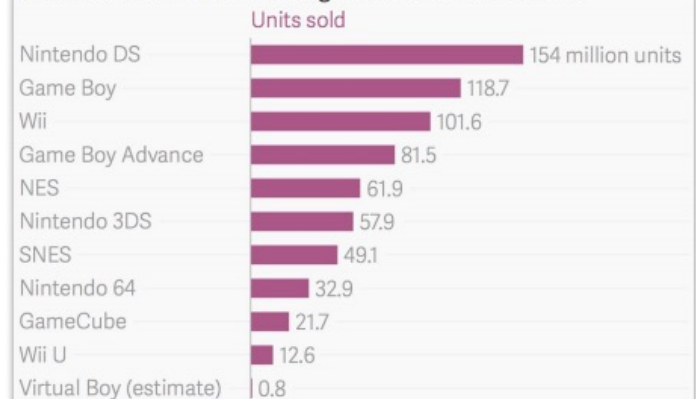
Nintendo Virtual Boy

- computer graphics & GPUs were not ready yet!

Game: Red Alarm



Total worldwide Nintendo videogame console sales to date



Where are we now?

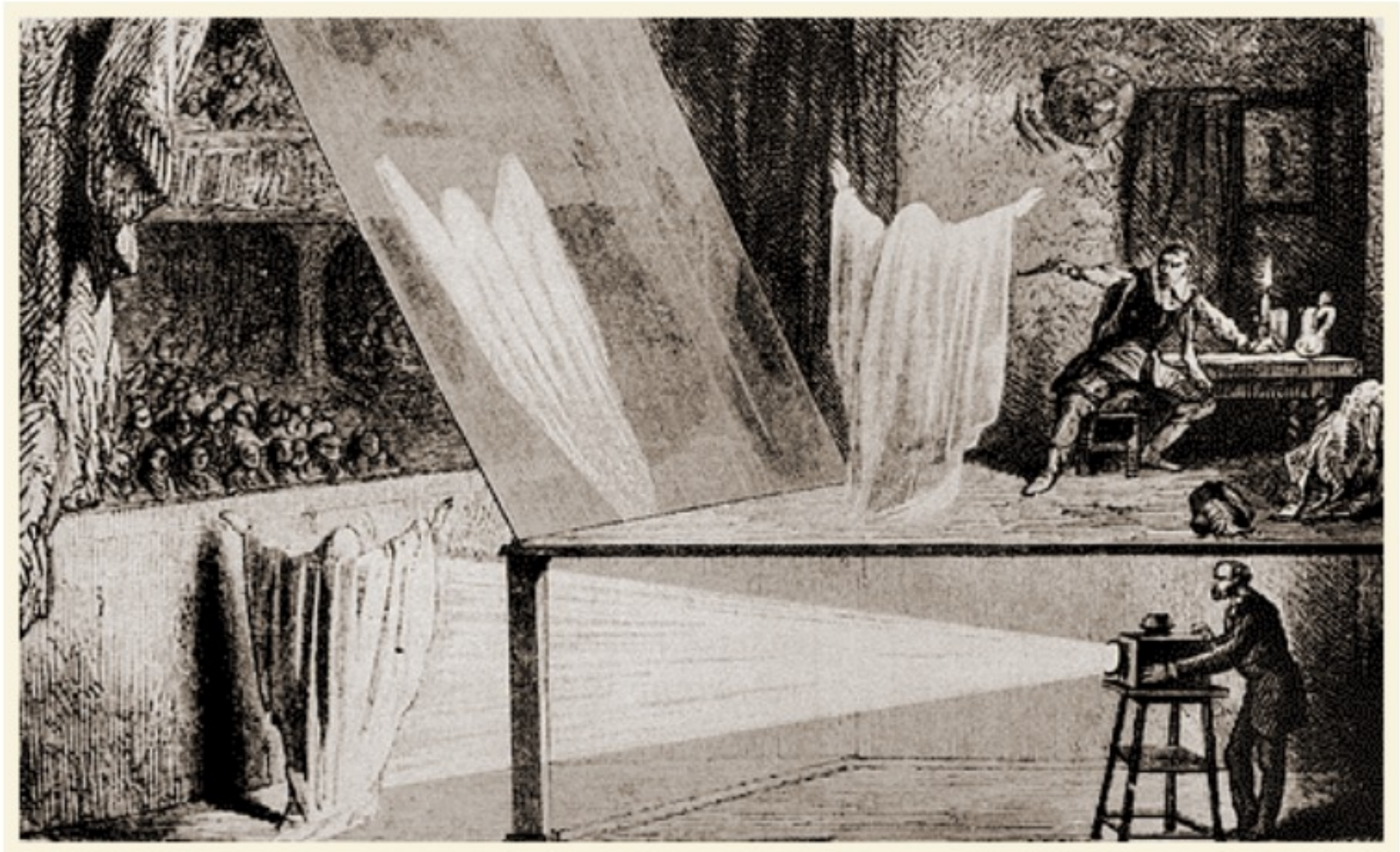


IFIXIT teardown

Augmented Reality

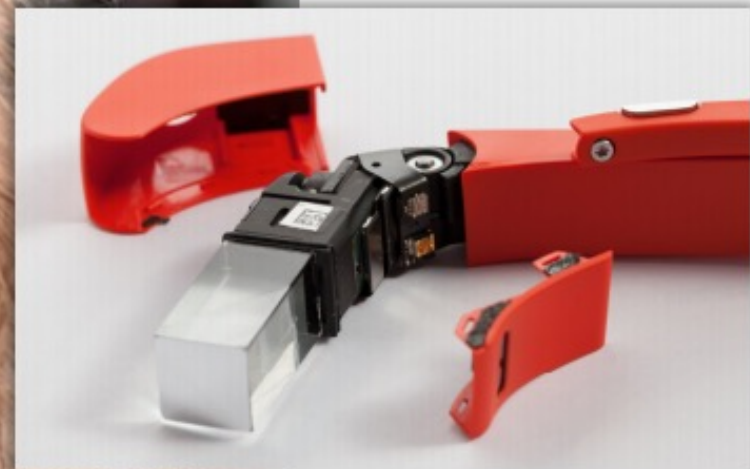
- Blends what the user sees in their real surroundings with digital content generated by computer software
- Not really covered in this class, but closely related

Pepper's Ghost 1862



Google Glass

Google Glass



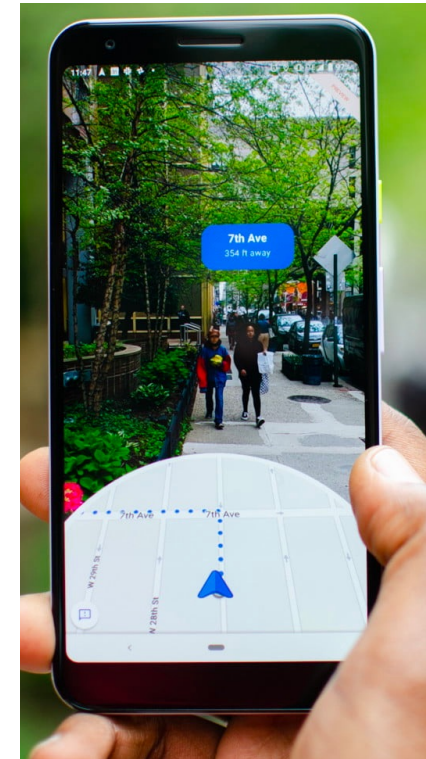
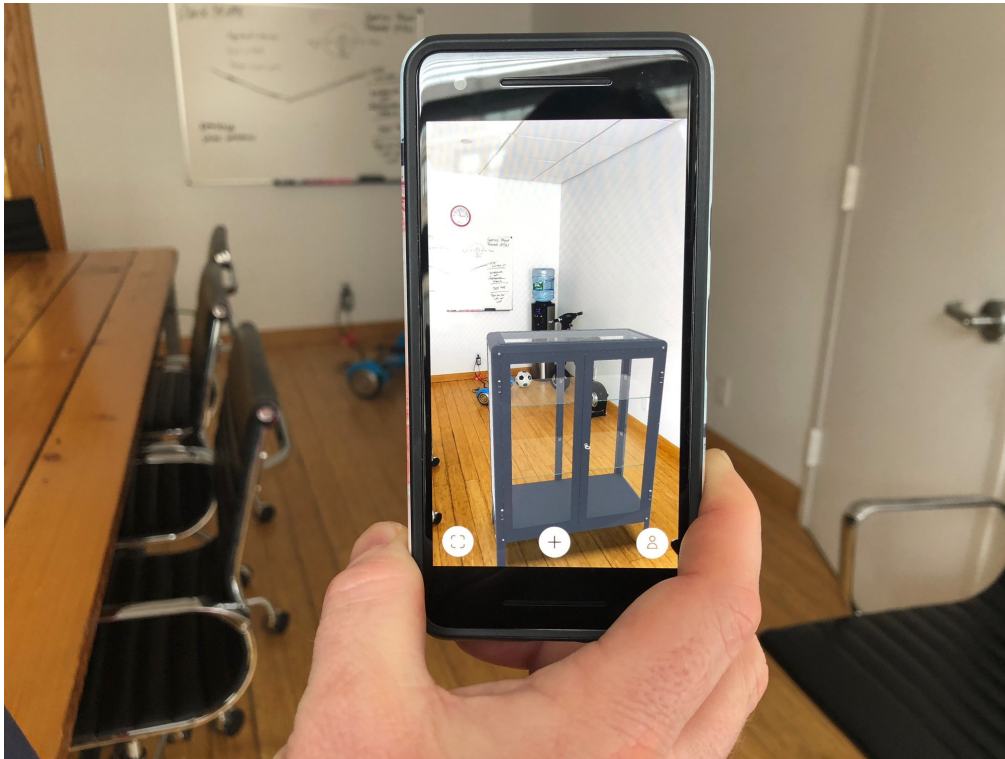
Microsoft HoloLens

- Small field-of-view, but excellent image quality



ARCore, ARKit, ARToolkit

- Development tools for AR development for Android (Google ARCore), iOS (Apple ARKit), and open-source library of AR applications (Github ARToolkit)



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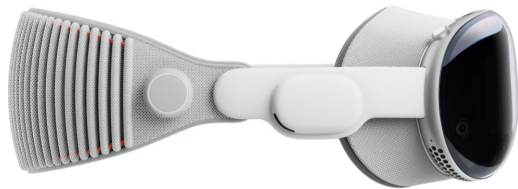
Glimpse of the Status Quo



Microsoft HoloLens 2



META Quest 3



Apple
Vision Pro



Valve
Index VR



Vive XR
Elite

VR before the 2000s

- VR has been an academic thing since WAY before the 2000s
 - 1950s – Morton Helig’s Sensorama
 - 1968 -- Ivan Sutherland
 - 1991 – Virtuality Group Arcade Machines
 - 1993 -- Sega announced a VR headset for the Genesis Console -> Never made it to the market (Motion Sickness)
 - Nintendo released the Virtual Boy in 1995



The big bang of VR



Palmer Luckey launched Oculus at age 19 after a successful kickstarter campaign, widely regarded with reviving VR industry

Result of the Kickstarter (2012)

- \$2.5M dollars in backer money
- Massive “public” recognition
- Industry hype



**2012 Best of E3 Nominee
(They didn't even have a product)**

From Development to Consumer Product

March 2013

640 x 800 per eye
60 Hz
110 Degree FOV



July 2014

960 x 1080 per eye
60 Hz
100 Degree FOV



March 2016

1080 x 1200 per eye
90 Hz
110 Degree FOV



Facebook acquired Oculus in 2014 for \$2B

Valve Coming out of the Closet

- Announced partnership with HTC in March 2015
- HTC and Valve are different corporations now with different products
- Full body tracking



HTC / Valve Status Quo



Vive Focus

- Standalone
- Inside Out 6DOF



Wireless Adapter

- Cordless VR



Vive Pro

- 1400 x 1600
- Built-in Audio



Valve Knuckles

- New Controller Design

Pimax 12k/ 8k / 4k

- Kickstarter started in 2017
- Delivery available now!

Pimax: The World's First 8K VR Headset



Pimax 8K allows users to experience VR with Peripheral vision while solving the problem of screen door effect and motion sickness

Created by

Pimax 8K VR

5,946 backers pledged \$4,236,618 to help bring this project to life.

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About CS 410/510 VR Course

- Introductory course to VR fundamentals
- Introductory labs to Unity with AR/VR connections

Learning Goals

- Understand fundamental concepts of VR
- Learn about the very basics of VR/AR in Unity
- With only a single quarter, we have to be selective about the material we cover
 - This course is **not a full fledged course on unity**
 - We provide the basics and connections to AR/VR in a few lab sessions
 - Not a comprehensive course on VR either, perhaps we would need about two quarters to cover all aspects of VR

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Course Structure:

- **Lectures:** 11 lectures covered by the instructor
- **Labs:** 5 in-class Unity labs, where students are expected to install unity and do simple lab assignments
 - 4 Labs when offered in the summer
- **Exam:** One exam day, covering only the lecture material
- **Demo:** Unity, AR/VR on Phone, or Research presentation
 - Three sessions
 - No demo or projects when offered in the summer

Detailed schedule is available on canvas.pdx.edu

Course Evaluation I

- There will be two lecture-based homeworks covering the lecture material and two lab-based assignments based on the Unity framework
 - 40% of your total grade
 - 60% when offered in the summer
- Exam
 - There will be a single in-class exam. The exam will be **based on all the lecture material**. The exam will **be open notes and open books**.
 - 20% of your total grade
 - 30% when offered in the summer

Course Evaluation II

- Project presentation
 - **30% of your total grade**
 - The course contains a project, in which students are expected to develop a VR world in Unity and present it during the last two class sessions
 - Instead of project you can also do a research presentation
 - Some students may also do VR/AR presentation on their phones
 - We have a very few Oculus headsets
 - Different headsets and OSs is also another big problem

No project component when course is offered in the summer

Course Evaluation III

- Participation is 10% of your grade
 - Attendance (unless you have emailed me and taking class asynchronously)
 - Respect each other at all times
- Feel comfortable asking questions
 - It also gives energy to your instructors 😊
- Come talk to me if you have trouble getting a word in

Course Evaluation Summary

- When offered in fall/winter/spring:
 - Homework: 40% of Total Grade
 - Exam: 20% of Total Grade
 - Project: 30% of Total Grade
 - Participation: 10% of Total Grade
- When offered in summer:
 - Homework: 60% of Total Grade
 - Exam: 30% of Total Grade
 - Participation: 10% of Total Grade