Lecturers

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Other Guest Lecturers: CAC.berkeley
Other Resources @ Berkeley

Master of Engineering Program
Teaching technical expertise and leadership
Other Resources @ Berkeley

VR@Berkeley

- Founded in Spring 2015
- >200 members in each semester enrollment
Course Schedule

Week 1 (8-23): Introduction and Capstone Options
Week 2 (8-30): Human Perception in the Context of VR
Week 3 (9-6): Basic Unity3D/VR Programming Workshop
Week 4 (9-13): Course project proposal presentation
Week 5 (9-20): Computer Graphics related topics
Week 6 (9-27): 3D Vision related topics
Week 7 (10-4): Optics and Display technologies
Week 8 (10-11): Localization and Mapping

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Week 9: (10-18) VR Film Making (Richard Hernandez)
Week 10 (10-25): Gaming (Jack McCauley)
Week 11 (11-1): Telemedicine (Ruzena Bajcsy/Gregorij Korillo)
Week 12 (11-8): AR/VR in Arts & Design (Ted Selker)
Week 13 (11-15): Computational Imaging for VR (Ren Ng)
Week 14 (11-22): No class
Week 15 (11-29): Final project presentation
Week 16 (12-6): Final project presentation
Grading Policy

Your final grades will be determined by four factors:

1. Attendance by you (10%)

2. Interaction during the class given by the lecturers (10%)

3. Course/capstone project presentation (40%)

4. A research paper discussing your project and its relevant literature and commercial applications (40%)
Recommended Reading Material

• **Perception:** Sensation and Perception  
  by Bruce Goldstein

• **Virtual Reality:** Virtual Reality  
  By Steven LaValle (and checkout his YouTube lectures)

• **Computer Graphics:** Fundamentals of CG  
  by Peter Shirley

• **Computer Vision:** An Invitation to 3-D Vision  
  by Yi Ma, et al.

• **Display:** Mobile Displays  
  by Achin Bhowmik, et al.

• **AR/VR Market Research:** Virtual & Augmented Reality, understanding the race for the next computing platform  
  by Goldman Sachs
Goal of the Course

• Understand the fundamental theories that enable VR/AR and IC

• Understand the main technology drivers of VR/AR and IC markets

• Become an expert in criticizing the current software and hardware solutions

• Being about the invent new solutions that address existing needs / pain points of VR/AR and IC applications

• (Optional) Being motivated to pursue a career in relevant research or entrepreneurial fields
AR/VR: A Hot Market in 2016
Holodeck: A VR Experience
Leia’s Hologram: An AR Experience
Brief History of VR/AR/IC

- Graphics
- Photography
- Stereoscopy
- 3D Audio
- Interaction
Early Forms of Paintings and Arts

Cave paintings
Since 35,000 – 40,000 BP

Writing and languages,
Since 3100 BC
Early Forms of Photography

Camera Obscura, circa 400BC
First photo on paper, 1800s
Kodachrome, 1935
3D Illusion with Perspective

Ames Room, by Adelbert Ames, Jr., 1946
Seeing 3D from Stereo

Wheatstone mirror stereoscope, 1838

Holmes stereoscope, 1861
Audio: From Mono to Spatial 3D

Edison cylinder phonograph, 1899

Dolby Stereo, 1977

Invention of headphones, 1910s

Dolby Atmos for VR
Interaction Modalities

Keyboard, since 1860s

Mouse, Douglas Engelbart, 1963

iPhone, 2007
Hands as 3D Input Device
Sensorama: The First VR Prototype

Morton Heilig, 1958
Virtuality: Dawn of VR Gaming
Tilt Brush in Virtual 3D
CES 2017: Samsung 4D VR Experience
The First AR Prototype
Anatomy of an AR Device: HoloLens
Definition: Virtual Reality

- **VR** is a computer technology that uses head mounted displays, sometimes in combination with other sensory devices, to generate realistic images, sounds, and other sensations (touch, smell, motion, etc.) that simulate a user’s physical presence in a virtual environment.
Definition: Augmented Reality

- **AR** is a computer technology that augments a physical, real-world environment directly or through its indirect view computer-generated sensory information, including graphics, video, and sound. AR may alter a user’s view of reality, and may also enhance one’s perception of reality.
Enabling Technologies / Open Research

- Near-Eye Displays and Optics
- 3D Localization
- 3D Content Capturing
- New Human-Computer Interface
Near-Eye Optical Module

1. Create wide field of view
2. Place focal plane at several meters away from eye (close to infinity)

Note: parallel lines reaching eye converge to a single point on display (eye accommodates to plane near infinity)

Lens diagram from Open Source VR Project (OSVR) (Not the lens system from the Oculus Rift) http://www.osvr.org/
HMD Stereo Display Challenge
Localization via Beacons
Localization via Depth Perception

OmniVision
Microsoft
SONY
Intel
Google Tango Inside-Out Localization
360 VR Capturing: Photo Stitching

Google Jump VR
From 360 VR to Real-Time 3D VR
Lytro Immerge
New 3D Human–Computer Interface
New 3D Human–Computer Interface
Connecting AR/VR and Robotics
Course/Capstone Projects Examples

Berkeley OpenARK

- Lumus
- PMD
- Webcam
- Motion Sensor
- Microsoft Surface Pro
- <$5K per unit

SIEMENS

HUAWEI
STATE GRID CORPORATION OF CHINA
Berkeley UNIVERSITY OF CALIFORNIA
Beta released early 2017
ISAACS: Immersive Semi–Autonomous Aerial Command System

SEEING IS BELIEVING
Leveling up with augmented reality

When I was a kid, I would set off traversing orienteering courses through the hardwood forests of my native New England. The goal was to find a flag somewhere far off a trail using a topographic map and compass. It’s a very interactive process: I was constantly positioning the map, readjusting headings and trying to find discernible landmarks.

Sometimes I would end up lost; other times, with my bearing right on, I felt like a successful explorer, emerging from the untrammelled wilderness. It was a straightforward lesson about how using technology, albeit simple, changed the way I considered what was right in front of me.

I haven’t thought about orienteering in a long time. These days, my wayfinding needs are typically satisfied by opening Google Maps on my phone. But recently, as I sat down with electrical engineering and computer sciences (ECECS) major Daniel Pok and computer science major Isabel Zhang, the cofounders of a relatively new student organization called VR@Berkeley, my mind wandered back to my experiences with maps and compasses.

We talked about how virtual reality (VR) and augmented reality (AR)—once relegated to movie screens and sci-fi novels—are poised to revolutionize computing. Forty years ago, we saw AR’s potential in the opening scene of the “Star Wars” epic, when Luke Skywalker responds to a hologram of a distressed Princess Leia.

Today, if the recent Pokémon Go craze (where players blend the fictional world of Pokémon with real-world environments) is any indication, AR has arrived.

Through a combination of hardware and software, AR and VR convert computing from a flat two-dimensional screen to an immersive, interactive, three-dimensional experience. AR users wear a headset, but retain some visibility. Software is constantly mapping a user’s surroundings with efficient localization functions and then simultaneously overlaying digital images and interfaces in appropriate places in the real physical surroundings.

VR is a different experience: users wear an eye-covering headset, which serves as a wearable screen with embedded motion algorithms—a fully synthetic digital experience that is completely divorced from actual physical surroundings.

Pokémon Go isn’t quite AR because it uses a phone screen instead of a headset, so it’s not completely immersive. The game does, however, give a glimpse of where the technology is heading.

So far, commercially available VR applications include gaming and entertainment. While a few limited AR products are available now, Silicon Valley–based consulting firm Digt Capital predicts that the field will explode in market value, reaching $150 billion by 2020. Potential applications range from telemedicine to more intuitive control for robots on factory floors.

For Zhang, the technology is already life changing. She was carrying heavy biology-related course loads with aspirations of pursuing a career in medicine when Pok introduced her to VR. “I got interested in VR and then took an intro computer science course. After that, I decided to switch to computer science,” Zhang says. “So it’s definitely changed my life.” Now she’s creating immersive animated short films. “Watching a film in VR can create so much more emotion and evoke a lot more out of a wide variety of people. Being able to contribute to that is exciting.”

The VR club started with a handful of members in early 2015, and has since grown to 200 members across campus working on a range of projects, including making an augmented 3-D virus model that pops off the page of a biology textbook and how to use virtual reality to play the Compassion’s caution.

“The idea is that VR is the ultimate medium,” Pok says. “When you get there, you can shape the world however you want.”

Pok, Zhang and fellow members of Berkeley’s VR club are advised by Allen Yang, executive director of the Center for Augmented Cognition (CAC), headquartered in Cory Hall. Yang is working at a new frontier, one where the topography of the physical world is being reconfigured by digital tools.

“Yang came to Berkeley as an ECECS postdoctoral researcher in 2006. After a stint in industry as an employee number one at Atheer Labs, the maker of headsets that enable interactive computing, he returned to campus to lead CAC, along with faculty director Shashank Saxena, also dean of the college. The center opened this spring, after the college identified the need to integrate emerging research on virtual and augmented reality, including human-computer and human-robot interactions.

“We realized we needed two things,” Yang says about the center’s founding. “We need resources for researchers and students to be able to conduct projects or research in this area, and we need to have a community that can circle around this topic.”

Unlike many other university-based research areas, where commercial products follow theoretical research,
Drone Safety Control (Tomlin)

Safe Learning
with online model validation

Berkeley
University of California
VR in Autonomous Driving (Borrelli)