EE 267: Introduction and Overview

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Stanford University

EE 267 Virtual Reality

Lecture 1

stanford.edu/class/ee267/

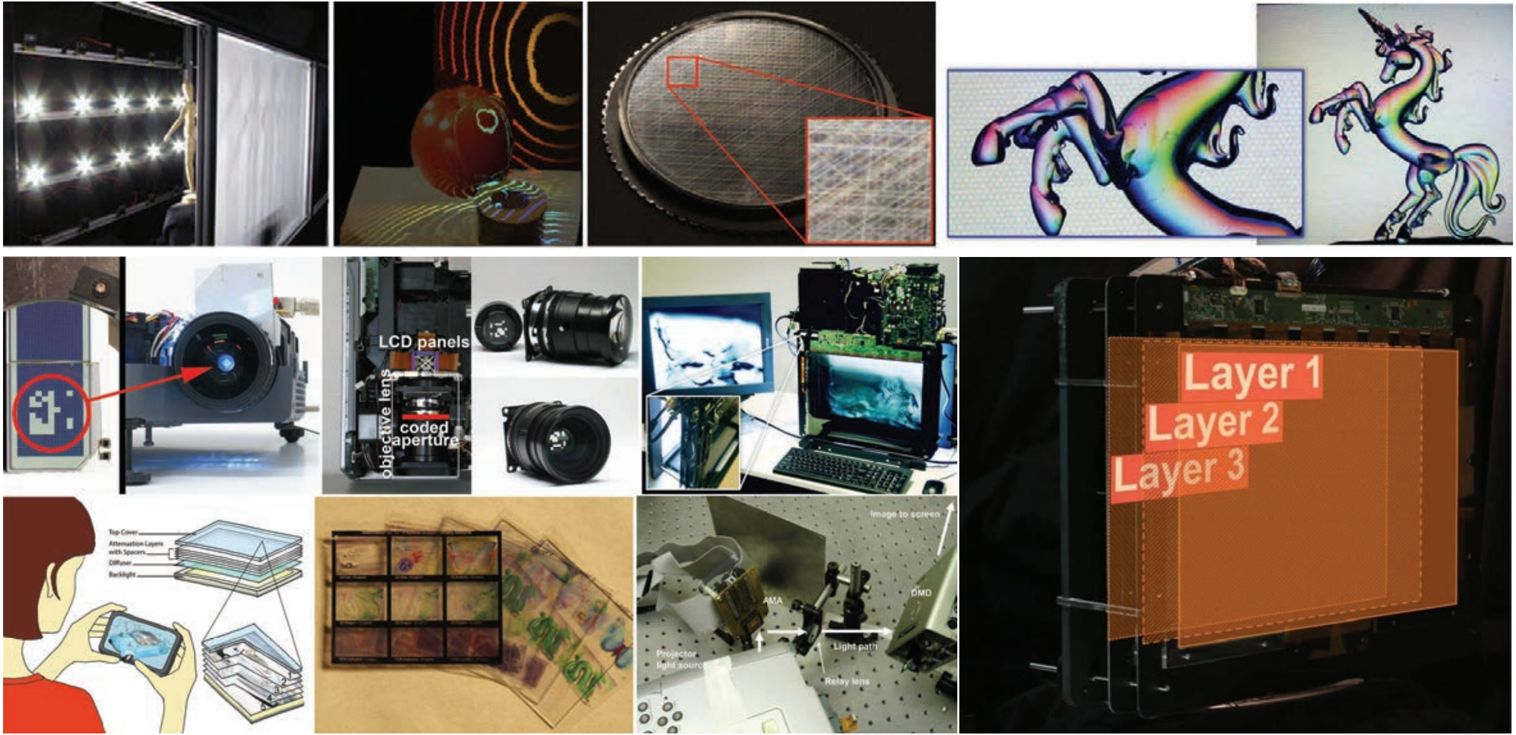
About Me
2003

VR Lab

Prof. Bernd Froehlich

Bauhaus University Weimar, Germany

~60 Projects on Cameras & Displays between 2003-2017



Oculus DK2 @ SIGGRAPH 2013

Oculus VR

Microsoft Hololens

simulation & training

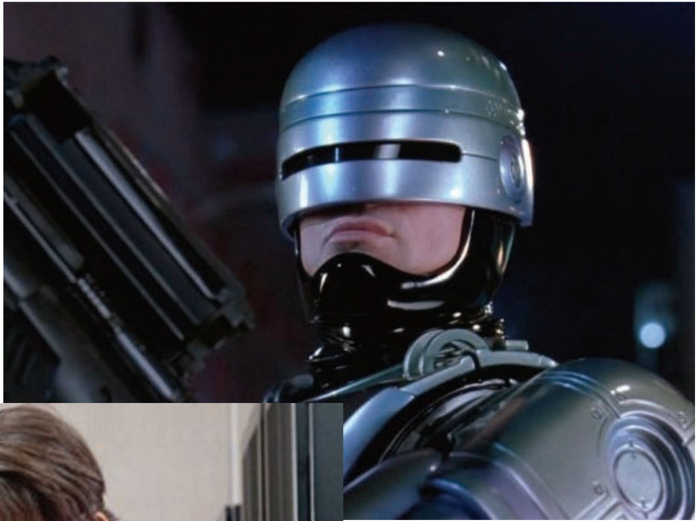
visualization & entertainment

gaming

robotic surgery

Consumer Applications – Prescription Glasses

slide by Bernard Kress

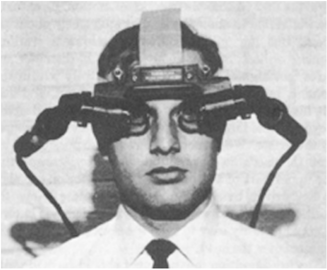


slide by Bernard Kress

A Brief History of Virtual Reality

Stereoscopes
Wheatstone, Brewster, …

VR, AR,
Ivan Sutherland



VR explosion
Oculus, Sony, Valve, MS, …

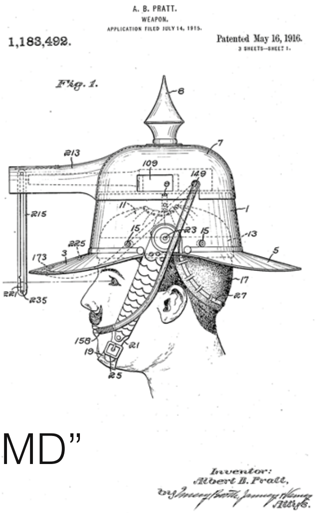
1838

1968

2012-2016

AR Displays

A Brief History of Virtual Reality



"HMD"

Nintendo Virtual Boy

VR explosion

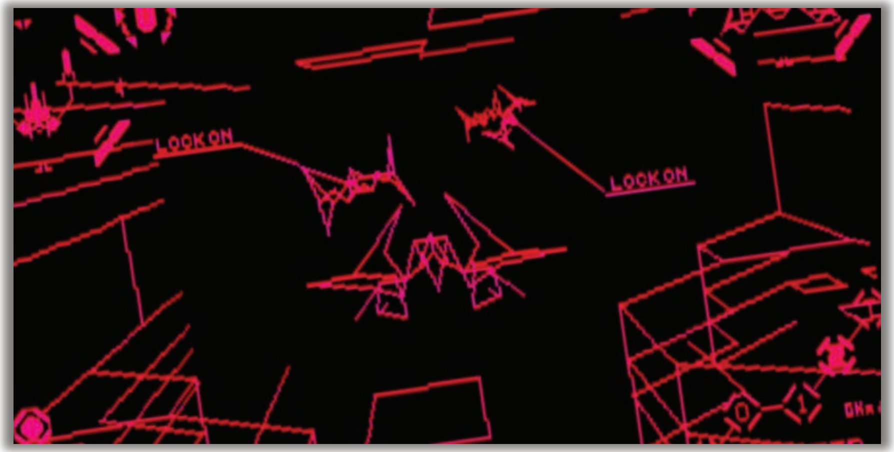
Oculus, Sony, Valve, MS, …

1838 1916 1968 1995 2012-2016

AR Displays

Nintendo Virtual Boy

- 770,000 units sold, commercial failure – judge for yourself



Game: Red Alarm

$\stackrel{?}{=}$

electronic /
digital

1968

HCI /
haptics

1980s

low cost,
high-res,
low-latency!

2000s

Ivan Sutherland’s HMD

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

I. Sutherland “A head-mounted three-dimensional display”, Fall Joint Computer Conference 1968

Oculus DK2 Teardown

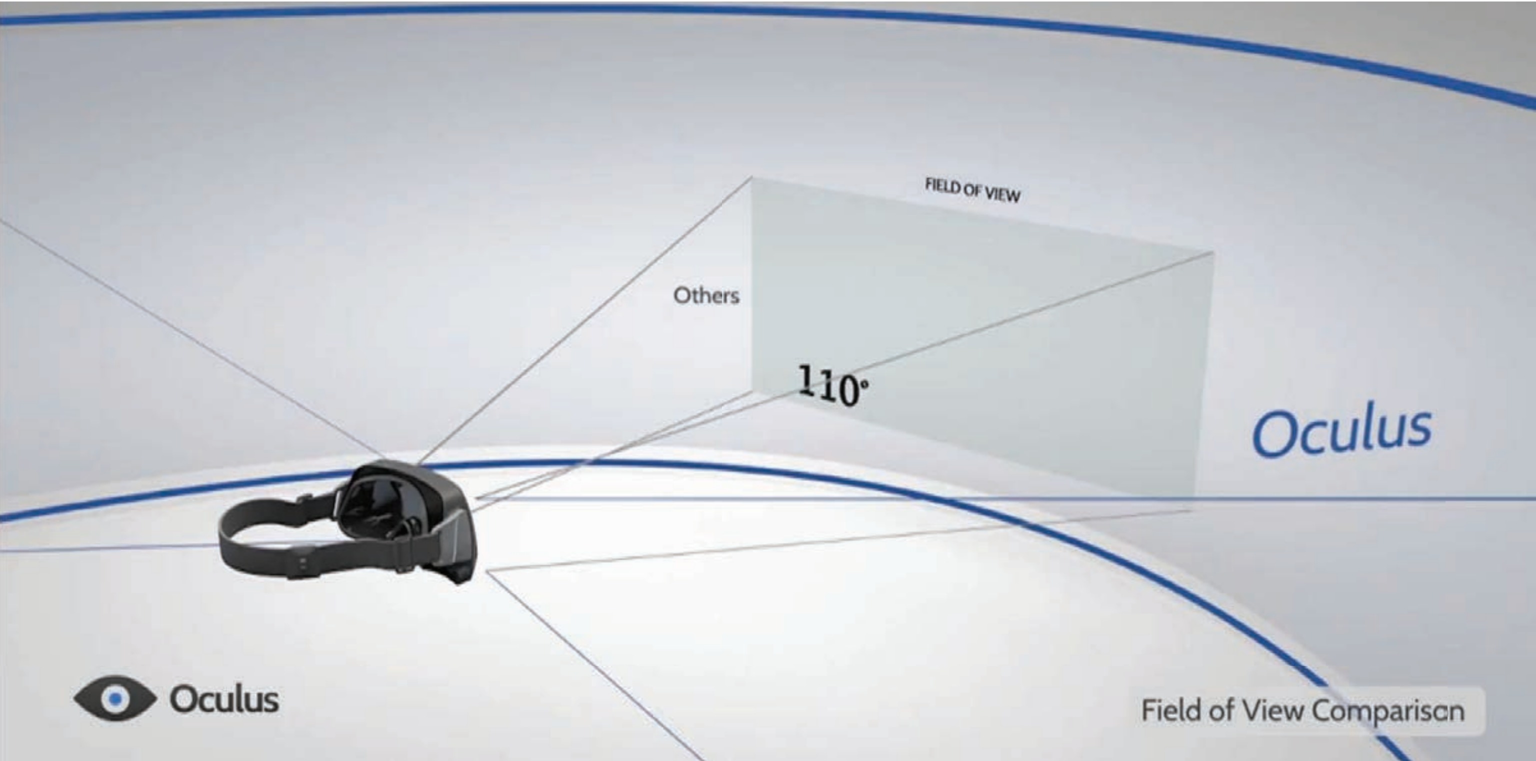
- Samsung 5.7” AMOLED: 1920x1080px, 75Hz
- 2 sets of lenses (for different prescriptions)
- InvenSense 6-axis IMU
- ARM Cortex-M3 MCU
- …

key factors:

low latency & wide fov!

https://www.ifixit.com/Teardown/Oculus+Rift+Development+Kit+2+Teardown/27613

Field of View!



Oculus DK2 Clones

Oculus Rift

Sony Morpheus

DuroVis Dive

VrAse

Zeiss Cinemizer

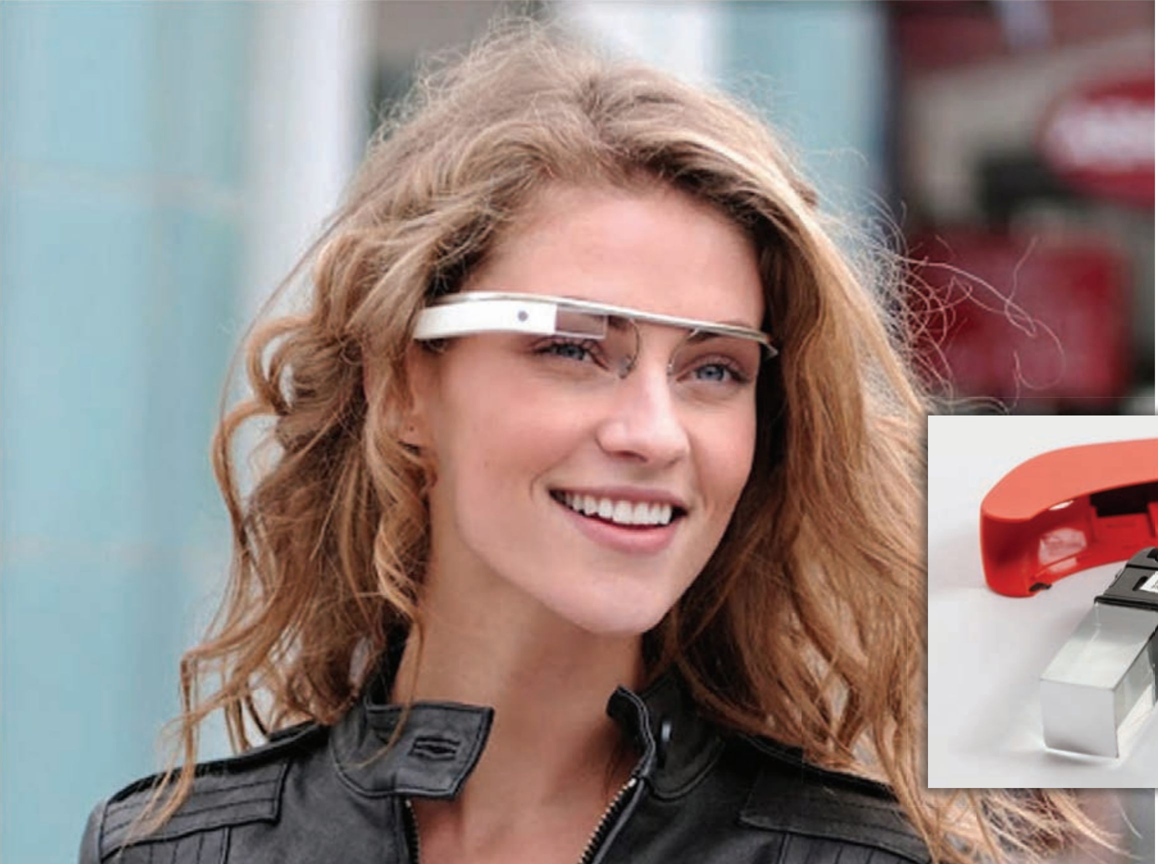
Avegant Glyph

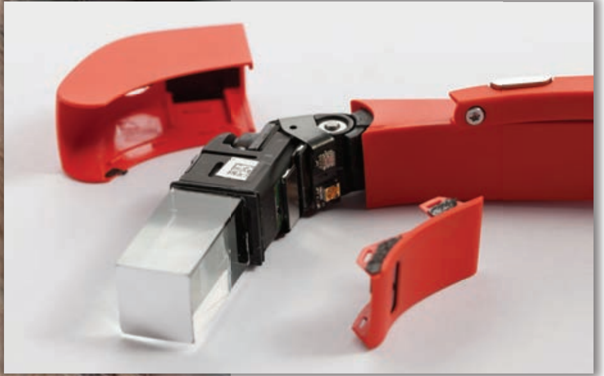
Hasbro My3D

Altergaze

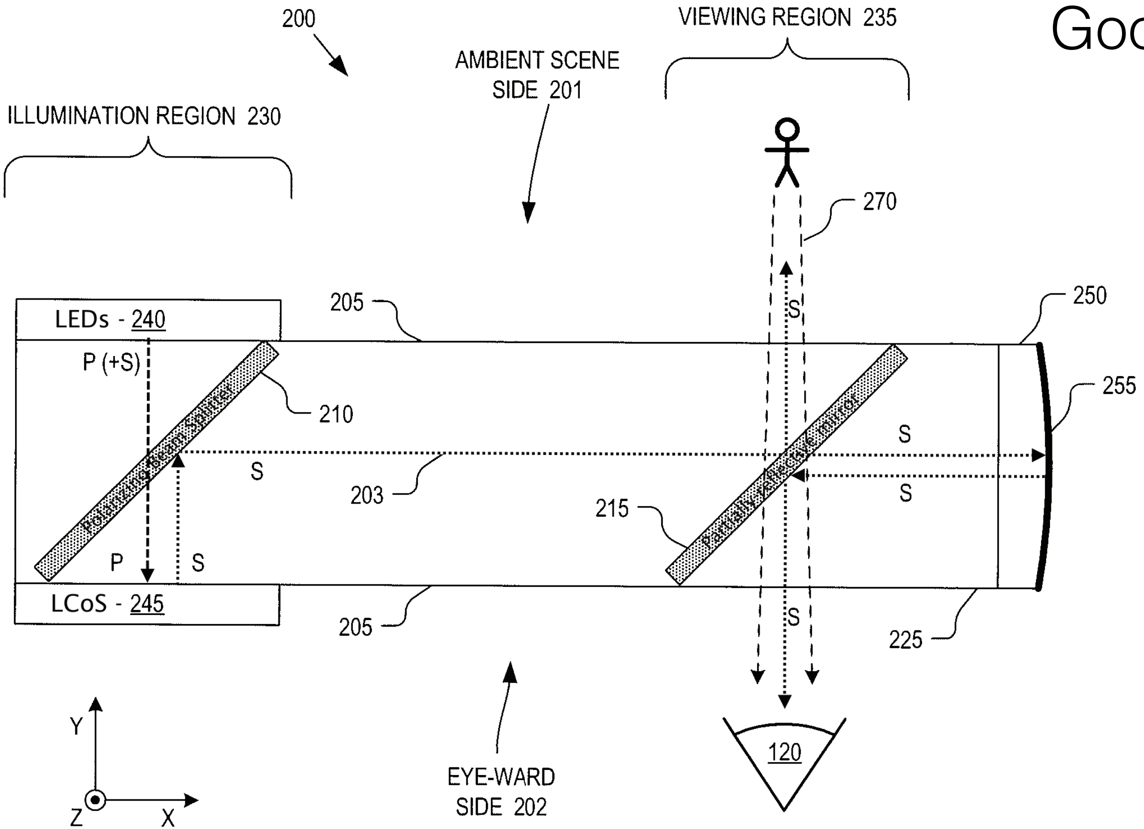
Google Glass

small!





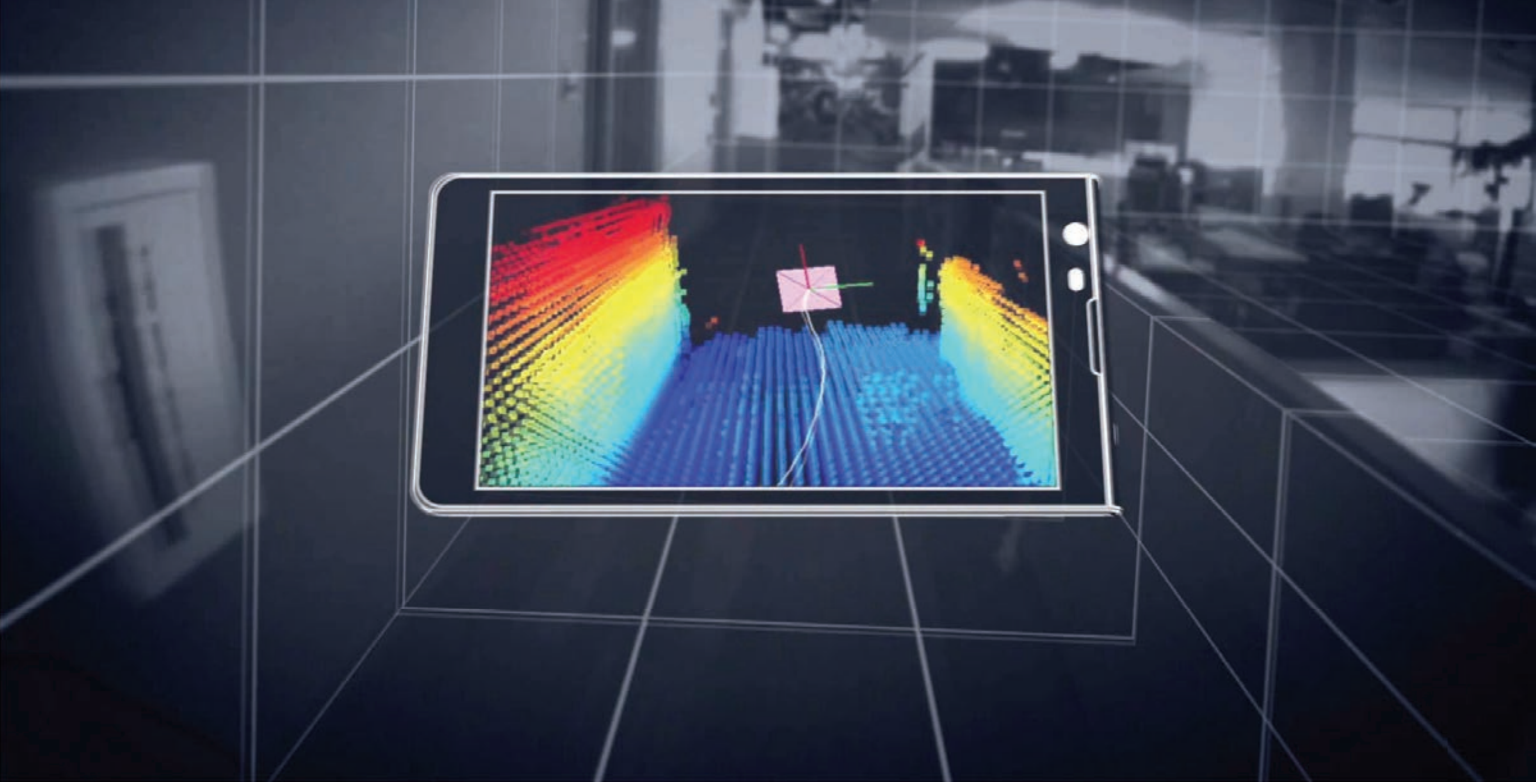
Google Glass



Pepper’s Ghost 1862

Microsoft Hololens – Time of Flight Sensor Array

Google Project Tango – SLAM / 3D Scanning



Iron Man

Taxonomy of Direct 3D Displays:

Glasses-bound vs. Unencumbered Designs

- **Glasses-bound Stereoscopic**
  - **Head-mounted** (eyepiece-objective and microdisplay)
    - Immersive (blocks direct-viewing of real world)
    - See-through (superimposes synthetic images onto real world)
  - **Multiplexed** (stereo pair with same display surface)
    - Spatially-multiplexed (field-concurrent) (color filters, polarizers, autostereograms, etc.)
    - Temporally-multiplexed (field-sequential) (LCD shutter glasses)
- **Unencumbered Automultiscopic**
  - **Parallax-based** (2D display with light-directing elements)
    - Parallax Barriers (uniform array of 1D slits or 2D pinhole arrays)
    - Integral Imaging (lenticular sheets or fly's eye lenslet arrays)
  - **Volumetric** (directly illuminate points within a volume)
    - Multi-planar (time-sequential projection onto swept surfaces)
    - Transparent Substrates (intersecting laser beams, fog layers, etc.)
  - **Holographic** (reconstructs wavefront using 2D element)
    - Static (holographic films)
    - Dynamic (holovideo)

Taxonomy adapted from Hong Hua

Taxonomy of 3D Displays:

Immersive Head-mounted Displays (HMDs)

Immersive
(blocks direct-viewing of real world)

Head-mounted
(eyepiece-objective and microdisplay)

Glasses-bound Stereoscopic

Multiplexed
(stereo pair with same display surface)

Taxonomy of 3D Displays:

See-through Head-mounted Displays (HMDs)

Glasses-bound Stereoscopic

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  (eyepiece-objective and microdisplay)
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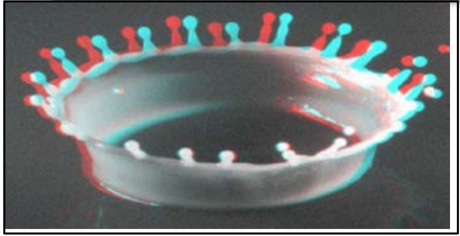
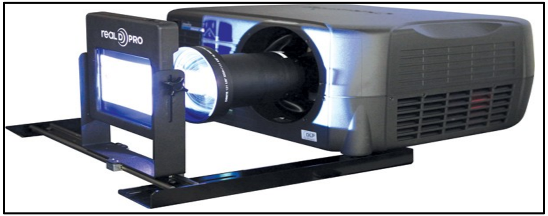
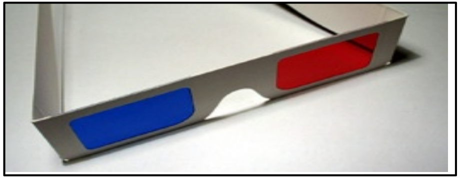
Taxonomy of 3D Displays:

Spatial Multiplexing (e.g., Anaglyphs)







Glasses-bound Stereoscopic

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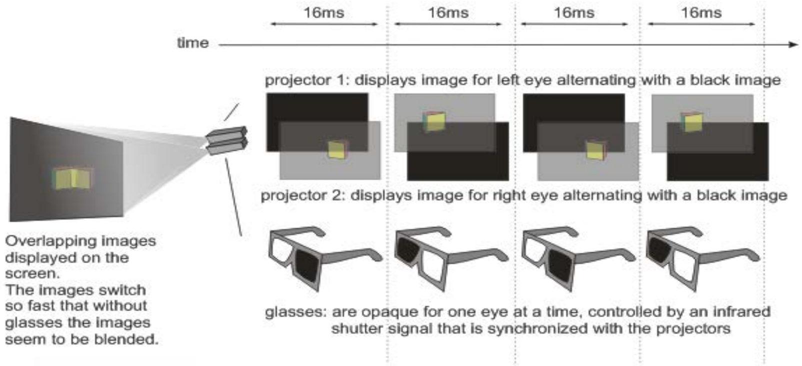
Taxonomy of 3D Displays:

Temporal Multiplexing (e.g., Shutter Glasses)



Glasses-bound Stereoscopic

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About EE 267

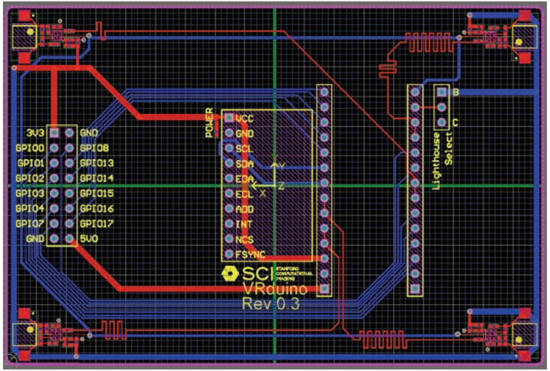
- experimental class, taught for the 2nd time (help us improve it!)
- lectures + assignments = one big project – <u>build your own VR HMD</u>
- all hardware provided, but must return at the end
- enrollment limited, because it’s a lab-based class and we only have limited hardware kits
- will be offered again (if students like the class)

About EE 267 - Goals

- understand fundamental concepts of VR and Computer Graphics
- implement software + hardware of a head mounted display
- learn basic WebGL/JavaScript and Arduino programming
- build your own HMD

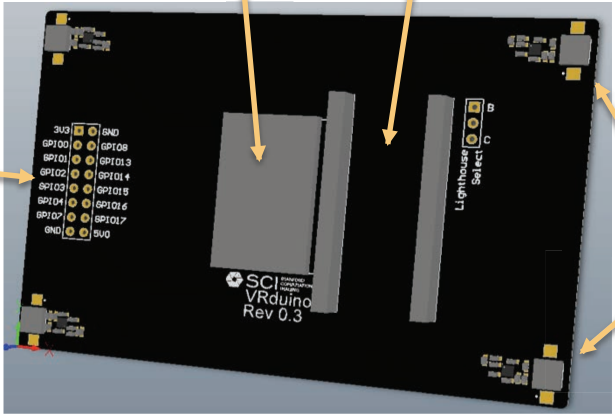
About EE 267 – DIY HMD

About EE 267 – VRduino



Teensy 3.2

IMU



other GPIO pins

4 photodiodes

About EE 267

- all important info here: http://stanford.edu/class/ee267/
- piazza: https://piazza.com/class/iyxrej40kso4af (see website)
- contact: ee267-spr1617-staff@lists.stanford.edu

About EE 267 - Prerequisites

- strong programming skills required (ideally JavaScript)
  do NOT take this course if you have not programmed!

- basic linear algebra required – we will start dreaming in 4x4 matrices

- introduction to computer graphics or vision helpful

About EE 267 – Lectures & Labs

- 2 lectures per week: Mo/Wed 3-4:20 pm, 380-380c

- 1 lab per week in Packard 001, every Friday (starting in week 1)

- labs - pick ONE time of: 9am, 11am, or 1pm

SIGN UP HERE:

https://docs.google.com/a/stanford.edu/spreadsheets/d/10tEwPrCnQqu9gQEpRNtJhcTe5xMc0X8WyGZ8mASwWwc/edit?usp=sharing

About EE 267 – Labs & Assignments

- lab every Friday in Packard 001 – attendance highly recommended!
- TA will help you get started, finish weekly assignment/project on your own
- 24h lab access will be provided after first lab (except for Fridays, during other labs)

About EE 267 – Lab Access

- review this website for lab policy: https://stanford.app.box.com/v/Basic-Lab-Safety

- to get ID access, email Steven Clark (EE teaching lab manager) your name & Sunet ID number (as well as an acknowledgement that you read the lab policy): steveclark@ee.stanford.edu

About EE 267 – Office Hours

- Gordon (instructor): Mondays 1:50-2:50pm, Packard 236
  come talk about projects, VR, course logistics, etc.

- Keenan (TA): Tuesdays 3-4:30pm, Packard 001
- Hayato (TA): Wednesdays 4:30-6pm, Packard 001
- Robert (TA): Thursdays 4:30-6pm, Packard 001

  come talk about labs, assignments, …

EE 267 – 3/4 unit version

Both versions:

- 7 assignments covering all aspects of VR tech

3 Unit version:

- 8th assignment (2 weeks)
- no report

4 Unit version:

- major final project – hardware, software, or perceptual experiments
- project report required (more details later)

Requirements and Grading

- 7 assignments (teams of ≤ 2): 70%
- 8^{th} HW or major final project (teams of ≤ 2): 30%
    - discuss project ideas with TA & instructor!
    - final presentation / demos: Friday of dead week in Packard 001 during your lab
    - reports & code due: Thu in finals week, midnight

Course Projects

- June 9 (during your lab session): project poster + demo session
  - see poster template on website
  - celebrate your work and connect with students, faculty, and industry!
  - may invite many people from industry: Oculus, Google, Magic Leap, Intel, Nvidia, Olympus, Canon, …

Course Projects – ONLY for 4 unit version

- June 12: report + source code due (at midnight)

- report = conference paper format ~6 pages with
  - abstract
  - introduction
  - related work
  - theory / background
  - results
  - discussion and conclusion
  - references
  - see latex template on website (will be there)

Possible Course Projects

- be experimental!

- for example:
  - psycho-physical experiments (e.g. test stereo rendering with color/gray, low-res/high-res, …)
  - build an elaborate virtual environment, e.g. with unity
  - hardware projects: IMU, positional tracking, eye tracking, haptics, …

Tentative Schedule

http://stanford.edu/class/ee267/