



Virtual and Augmented Reality

CS-GY 9223/CUSP-GX 6004

2023 Fall

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Introduction & Syllabus

The Instructors



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Virtual/Augmented Reality
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TBD

Guest Lecturers



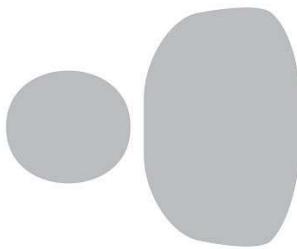
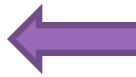
nVIDIA



Adobe



TANDON
SCHOOL OF
ENGINEERING



NYU

This Course is about:

Bottom-up knowledge development of theoretical foundations,
modern implementations, and state-of-the-art research on VR/AR,

and your **hands-on development!**

This Course is NOT about:

- Game development (shared platforms though)
- Web development
- High-level “seminar” or “overview” – you will need to **program**
- “Metaverse” or HCI
- Job interview “puzzles” – we develop the skillset

You Can/Should:

- Interrupt me anytime
- Ask technical/engineering questions to me/CA
- Discuss with peers
- Version control your code (we'll cover this today)
- Request extension/absence with a reason
- Come to office hours (we host it every week)

You **CANNOT**:

- Teamwork – independent work in the whole course, unless with discussed agreement for final project
- copy code/text from online/others/any without **acknowledging**
- **F** if you do any of these

Logistics (To Be on Brightspace)

- Office Hours: In-Person + Zoom
- Instructor:
 - 1H weekly (+1 around deadline)
- CA:
 - 1H weekly
- Tech Tutorials:
 - Unity tutorial
 - LaTex (next week)
- Slides uploaded before lectures

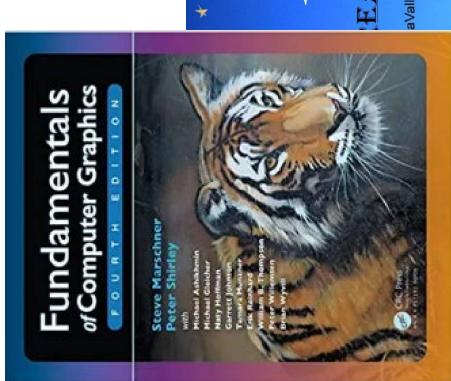
Syllabus

Prerequisites

- Mathematics
 - Basic Linear algebra (we will cover today)
- Programming
 - C#/Unity
 - (Preferred) Real-Time Graphics
- Academic Writing
 - Latex (with Tutorial)



Materials



Grading Overview

- 15% × 4 Assignments (including mini-projects)
- 5% Final Project Proposal + Survey
- 30% Final Project (including presentation)
- 5% Final Project Report

Breakdown & Assignments

- Assignment 1-2: Development foundations & real-time graphics
- Assignment 3-4: mini-projects with Cardboard (Unity-based)

Article & Final Project

- Option 1: Your research project
- Option 2: Reproduce a recent IEEE VR/ISMAR/SIGGRAPH paper
- Option 3: Real-world application

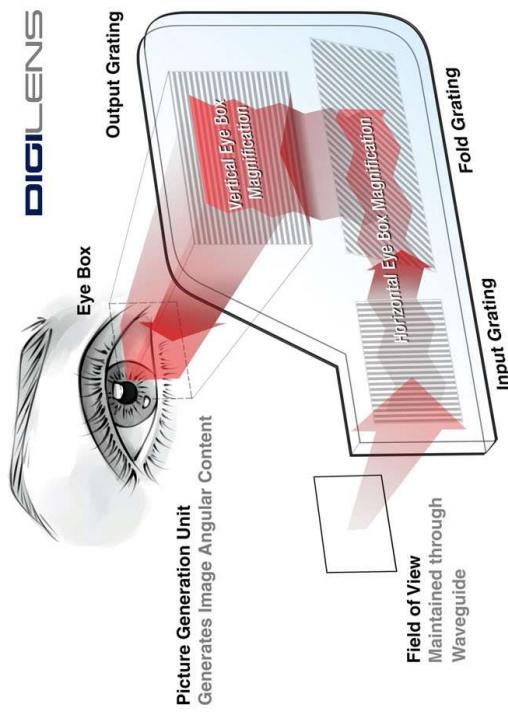
Device:

- (Default): Smartphone-based ARCore/ARKit
- Special request: early fulfillment

Course Content

VR/AR

An emerging medium & interface that integrates computer graphics/vision, physics, and cognition





VR/AR Components



History of Computer Media



History of VR/AR



1838: Stereoscopes

1968: "VR"
- Ivan Sutherland

1995: Virtual Boy
- Nintendo

~2012: The Explosion
Oculus, Sony, HTC, MS

Applications of VR/AR

simulation & training



visualization & entertainment



remote control of vehicles e.g. drones



gaming



robotic surgery



education

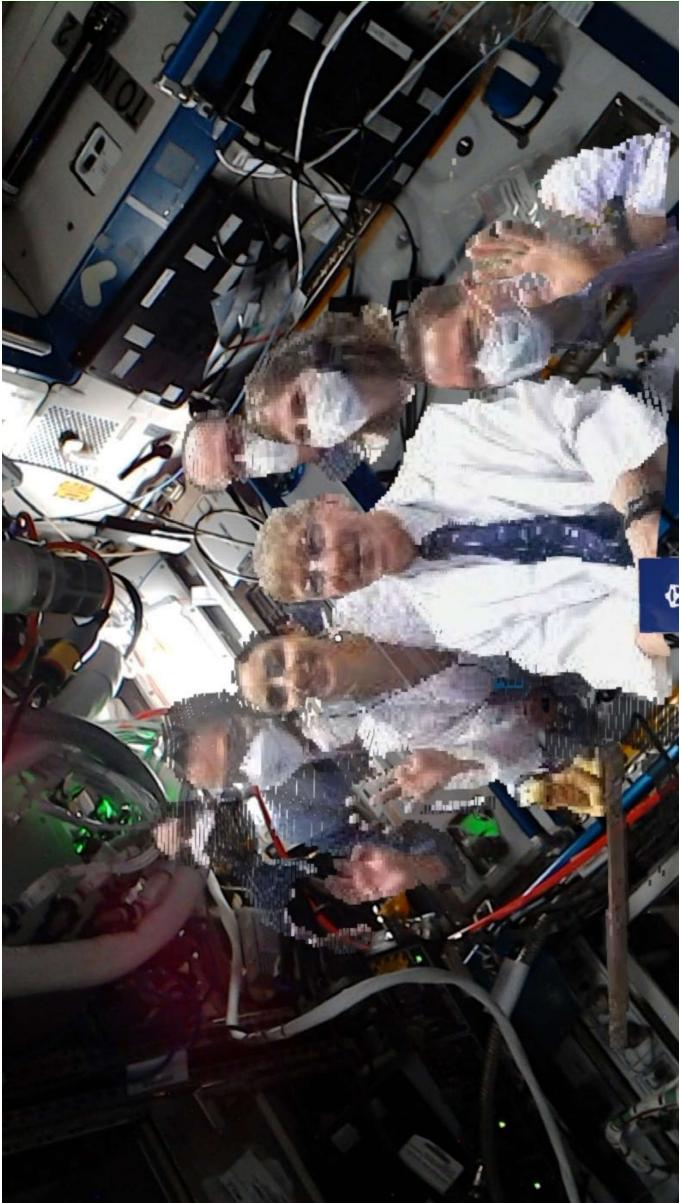


virtual travel

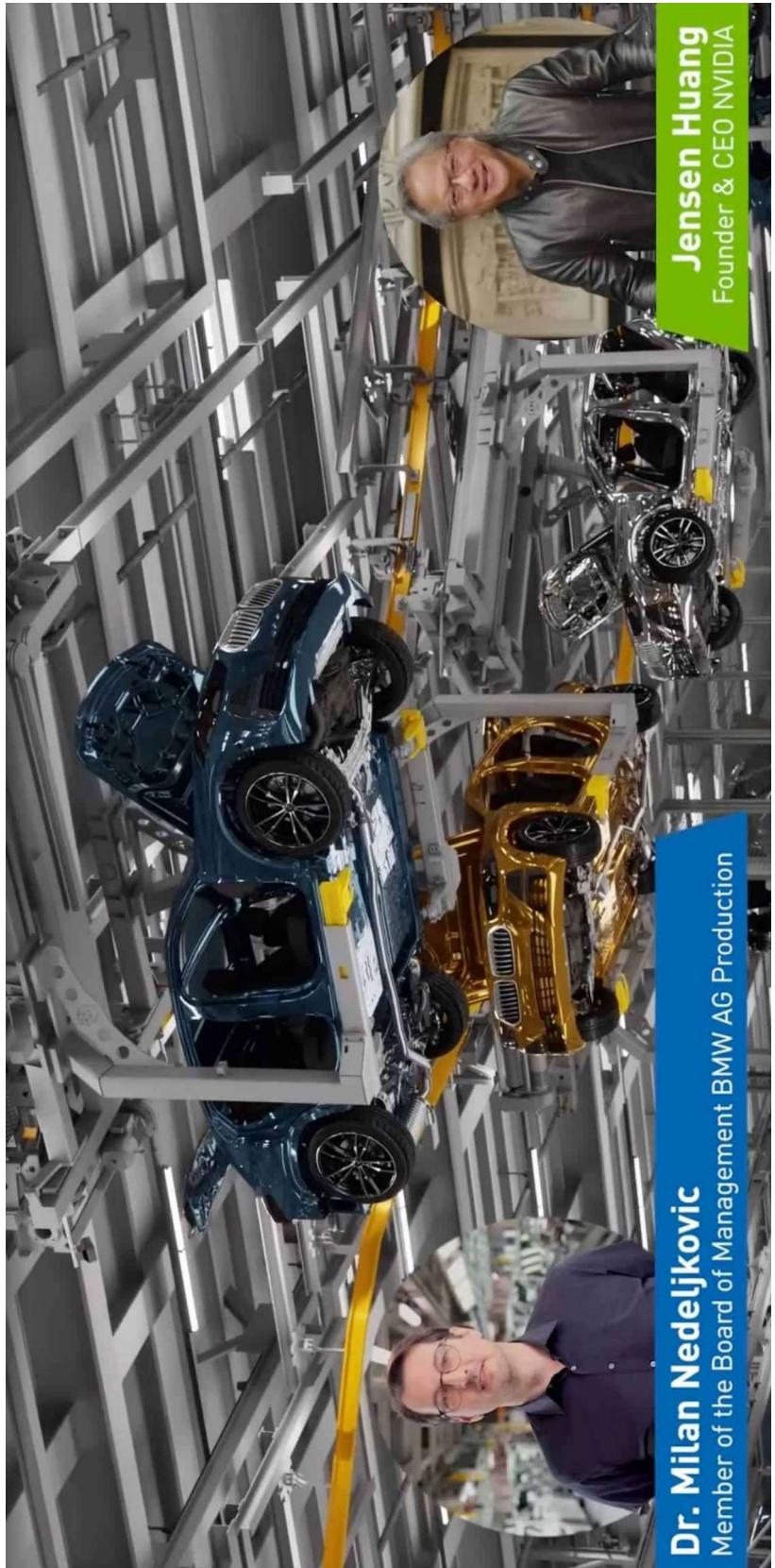
Applications of VR/AR @ NYU Langone



Applications of VR/AR @ NASA



Applications of VR/AR @ NVIDIA



Topics in this Course

- Mathematical foundations (programming algebra transformation/projection)
- Basic low-level real-time computer graphics
- Basic optical foundations (e.g., holograms, light fields)
- Human visual system and perception
- Tracking technologies
- State-of-the-art research and applications

Opportunity to meet leading industrial/academic researchers (*TBD*)
 **NYU**

Sutherland's VR/AR

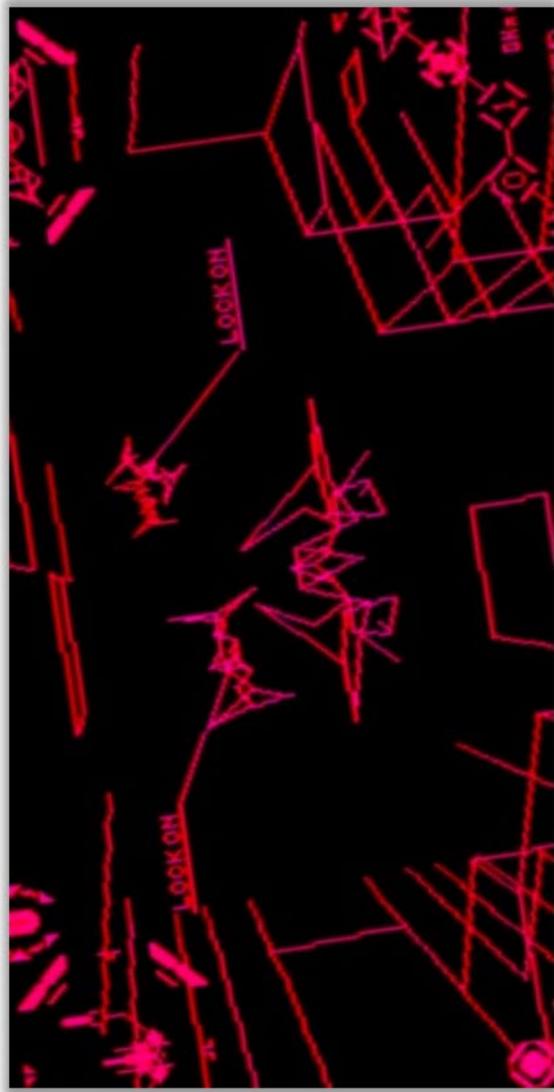
- optical see-through AR, including:
 - displays (2x 1" CRTs)
 - rendering
 - head tracking
 - interaction
 - model generation
- computer graphics
- human-computer interaction



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

Nintendo Virtual Boy

- computer graphics & GPUs were not ready yet!



Game: Red Alarm



Today: \$364.9 billion by 2030, ~20% of Meta



Platforms and Taxonomy

- VR headset



Platforms and Taxonomy

- VR headset - Accommodation Challenges

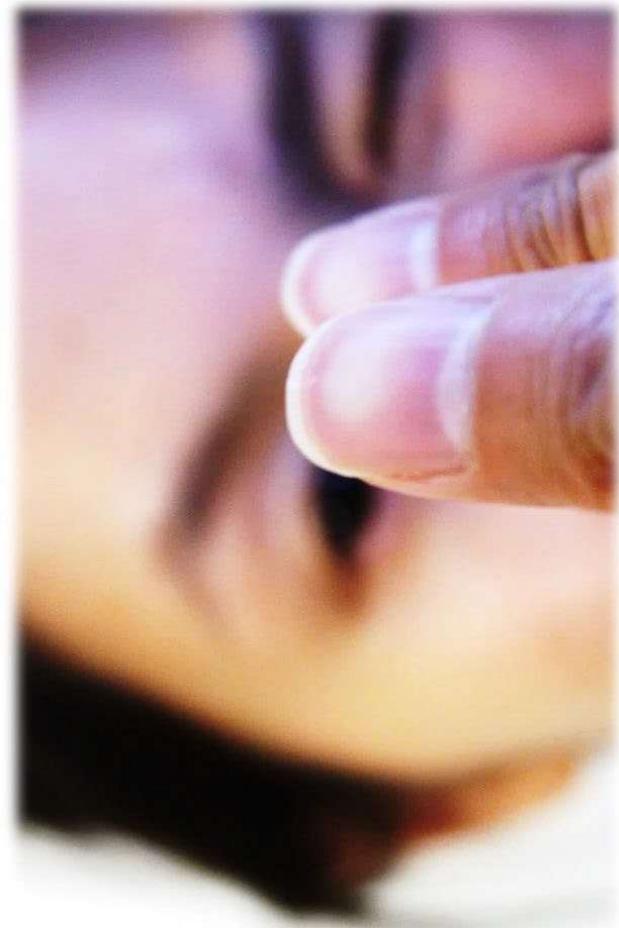
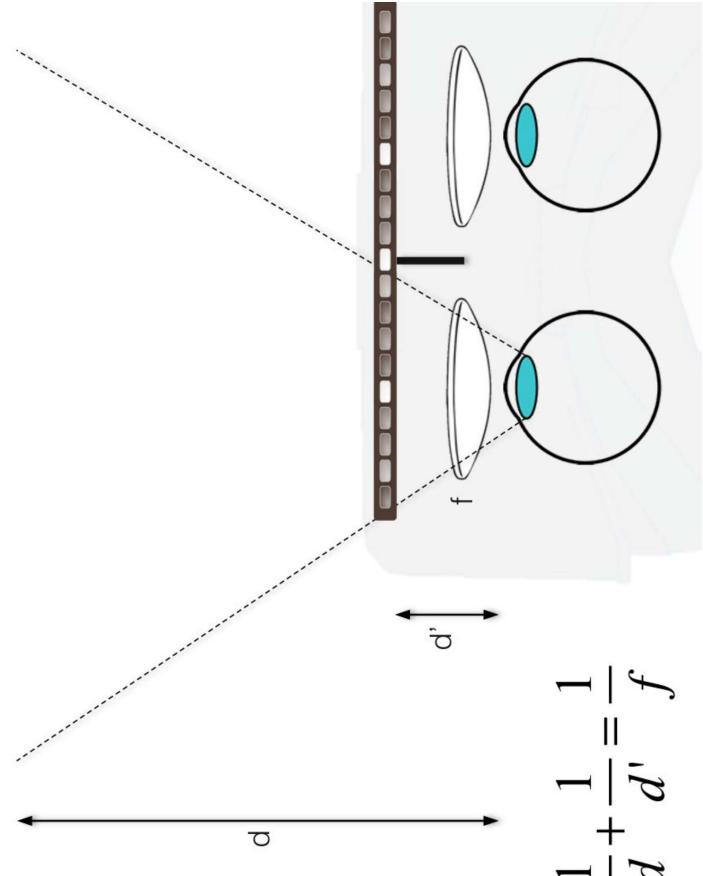
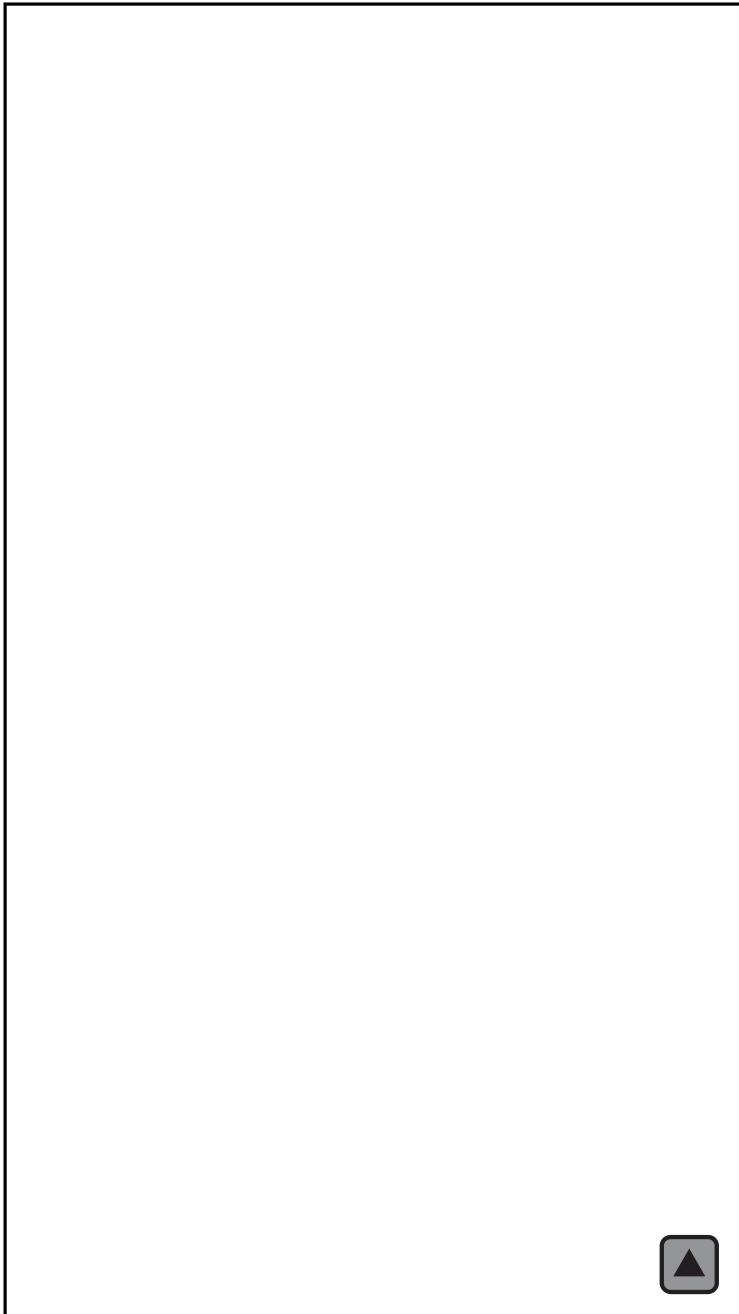


Image credit: Gordon Wetzstein @ Stanford

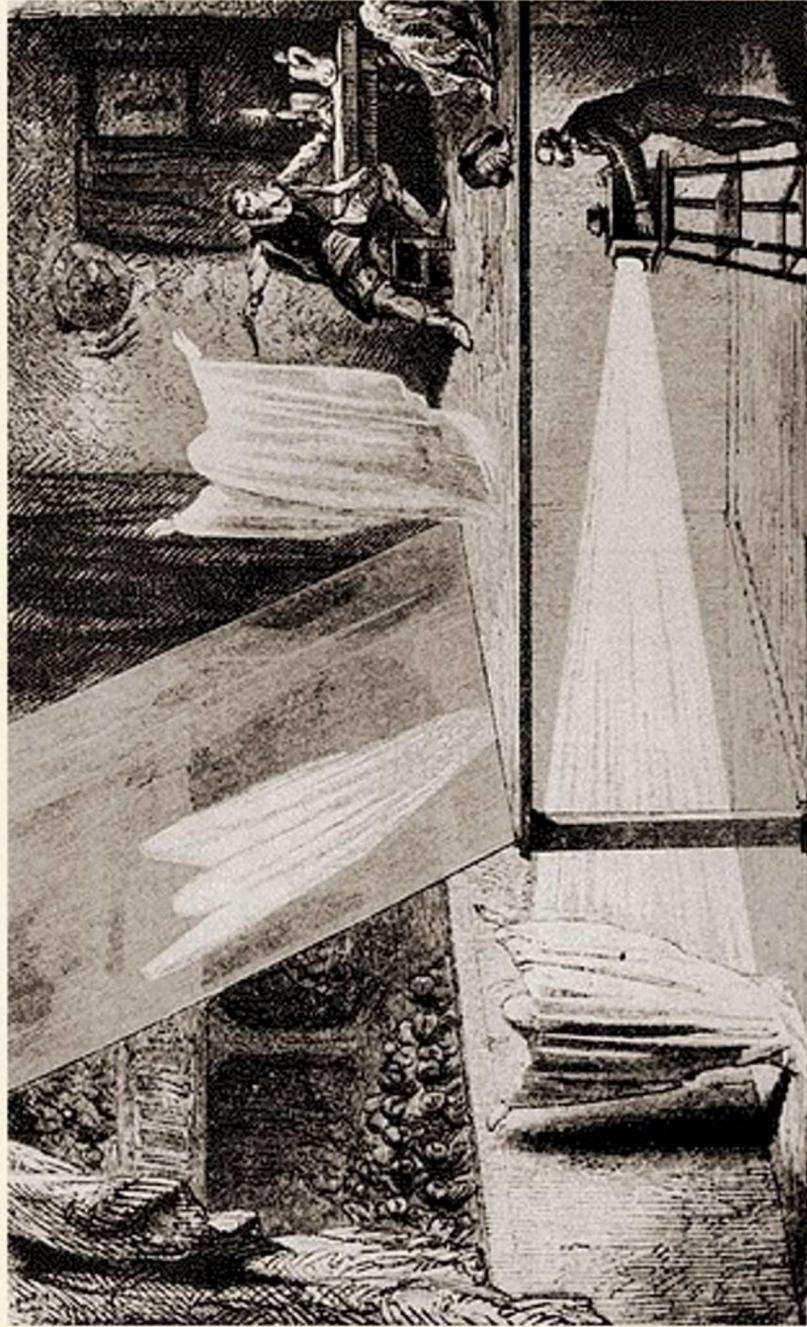
Platforms and Taxonomy

- VR headset – Spatial Challenges



Platforms and Taxonomy

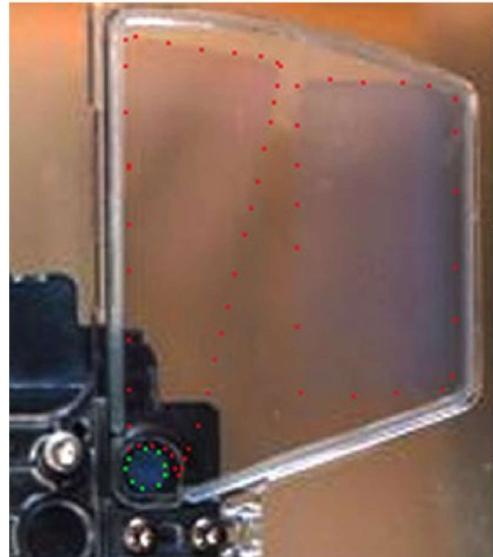
Pepper's Ghost 1862



- VR headset
- AR headset

Platforms and Taxonomy

- VR headset
- AR headset



US 2016/0231568 A1

(19) United States
(12) Patent Application Publication
Saarikko et al.
(45) Pub. Date: Aug. 11, 2016

- VR headset
- AR headset

(54) **WAVEGUIDE:**
(71) Applicant: Microsoft Technology Licensing, LLC,
Redmond, WA (US)
(72) Inventor: Paul Saarikko, Espoo (FI); Prod.
Kustannus, Espoo (FI)
(73) **U.S. C.3:**
CPC — **GR2B P700(72)** (2011.01); **GR2B 6.00(72)**
(2011.01); **GR2B 5A4(2)** (2013.01); **GR2B 20217.00(72)**
20217.00(1) (2013.01); **GR2B 20217.00(73)**
(2014.01)

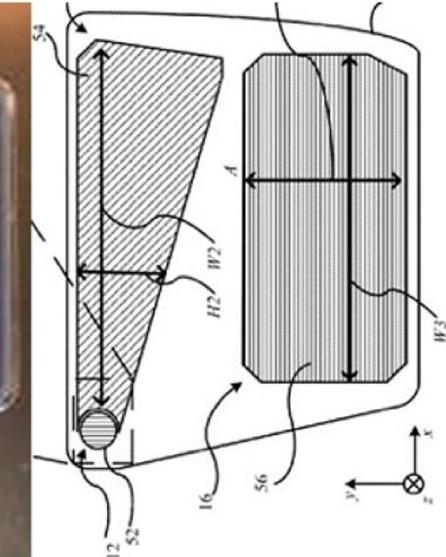
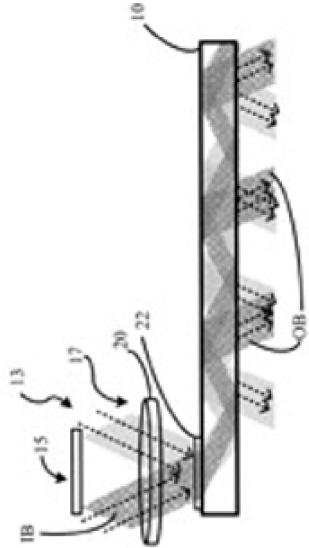
ABSTRACT

A waveguide has a front and rear surface, the waveguide for a display system and arranged to guide light from a right eye onto an eye of a user to make an image visible to the user. The light guided through the waveguide by reflection at the front and rear surfaces. A first portion of the front or rear surface has a structure which causes light to change phase upon reflection from the first portion by a first amount. A second portion of the same surface has a different structure which causes light to change phase upon reflection from the second portion by a second amount different from the first amount. The first portion is offset from the second portion by a distance which substantially matches the difference between the second amount and the first amount.

(57) **Publication Classification**

(51) Int. Cl.
GR2B 7/00
GR2B 7/04
PCT/EP 2014/069

(2006.01)
(2006.01)
(2006.01)



US 2016/0231568

Fig. 3B

Platforms and Taxonomy



- VR headset
- AR headset
- Video/Smartphone-Based
 - AR Core/AR Kit

Academic Skills to Develop

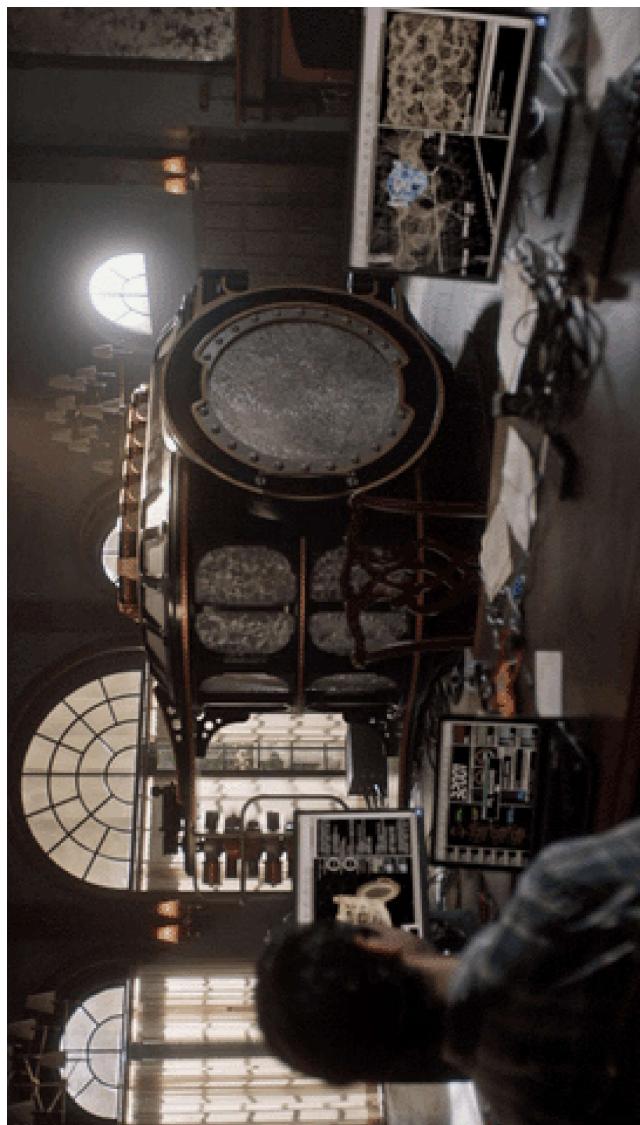
- Maths & engineering (proficient Unity development)
- Reading
- Literature survey and academic writing
- Presentation

Version Control 101

Git or Unity Cloud

What is version control?

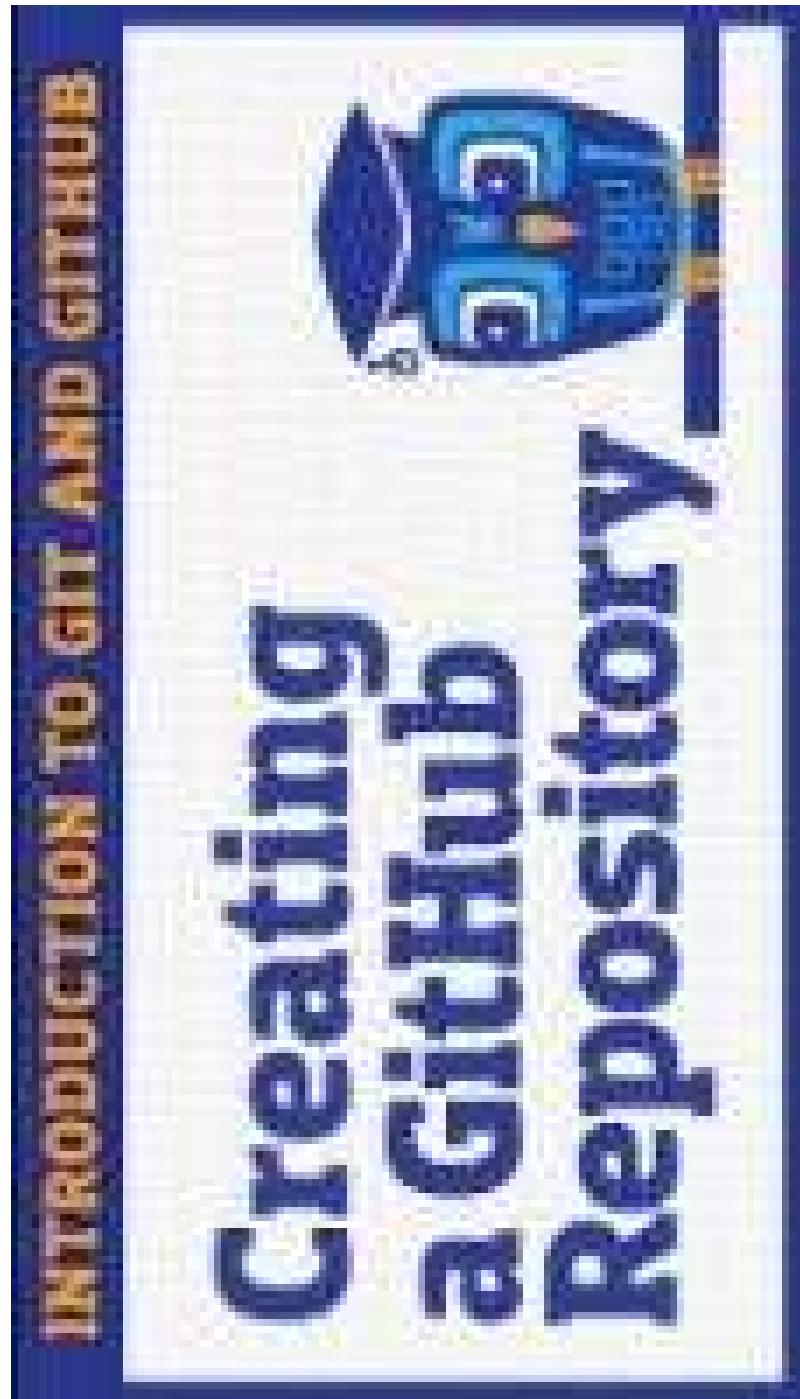
- managing multiple versions of documents, programs, web sites, etc



Version control is your friend - Why?

- For working by yourself:
 - Gives you a “time machine” for going back to earlier versions
 - Gives you great support for different versions (standalone, web app, etc.) of the same basic project
- For working with others:
 - Greatly simplifies concurrent work, merging changes
- Basic skill for internships/industrial job

1. Git and Github



How to version control: git and github

1. cd to the project directory you want to use
2. Type in `git init`
 - This creates the repository (a directory named `.git`)
 - You seldom (if ever) need to look inside this directory
3. Type in `git add .`
 - This adds all your current files to the repository
 - Period means “this directory”
4. Type in `git commit -m "Initial commit"`
5. type in `git push origin master`



How to version control: git and github

- `git clone URL`
- `git clone URL mypath`
 - These make an exact copy of the repository at the given URL
- `git clone git://github.com/rest_of_path/file.git`
 - Github is the most popular (free) public repository
- All repositories are equal



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source: David Matuszek

2. Unity Version Control (DevOps [Former Plastic SCM])

<https://www.plasticscm.com/>

Video Tutorial: https://www.youtube.com/watch?v=lSW2nS_v3lc