



JOHNS HOPKINS

WHITING SCHOOL  
of ENGINEERING

# Augmented Reality (EN.601.454/654)

Fall 2022

Alejandro Martin Gomez, Dr. rer. nat.





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# General Description

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- Instructor: Alejandro Martin Gomez
- Student Level: Undergraduate/Graduate (Applications)
- Prerequisites: Linear Algebra, Intermediate Programming, Data Structures
- Textbooks:
  - Schmalstieg, Dieter, and Tobias Höllerer. *Augmented reality: principles and practice*. Addison-Wesley Professional, 2016.
  - Hartley, Richard, and Andrew Zisserman. *Multiple view geometry in computer vision*. Cambridge university press, 2003.
    - Both books are available using our library resource

# General Description

- Course Description:

This course presents an introduction to augmented reality technologies, with an emphasis on designing and developing interactive augmented and virtual reality experiences. The course will cover the history of the area, interaction techniques, and specific application areas. The course also discusses the main issues of calibration, tracking, sonification, advance visualization and display technologies.





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# Objectives

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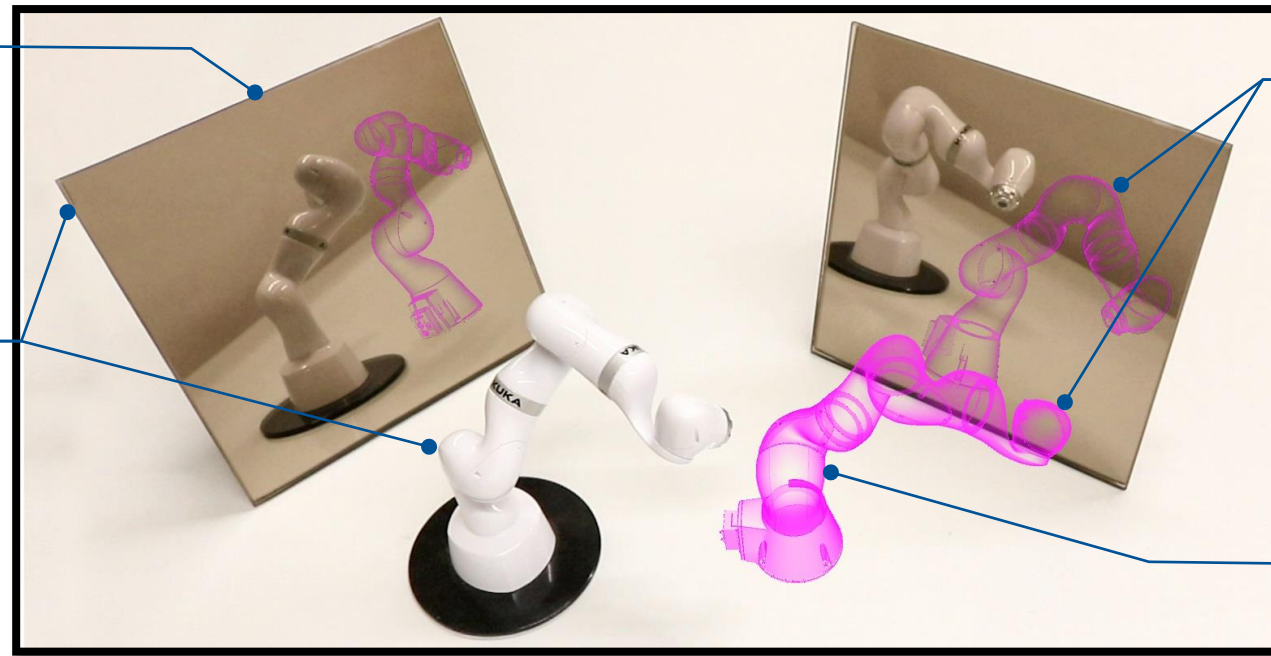
- By the end of this course, you will be able to identify and understand the basic components of an augmented reality application.

# Objectives

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Object Tracking

Real Content



Virtual Content

Rendering

# Objectives

- By the end of this course, you will be equipped with the necessary tools to design and implement your own augmented reality applications.



# Objectives



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**Speed 2x**

# Logistics



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# Logistics

- **Lecture:** 2 sessions of 1 hour and 15 minutes each
  - **Time:** Tuesdays and Thursdays from 15:00 to 16:15
  - **Location:** Maryland 310
  - **Website:** TBD (Most probably, we will use a GitHub Page)
- **Office Hours:** 2 hours per week
  - **Lead Teaching Assistant:** Irene Kim will reach out to you with further details





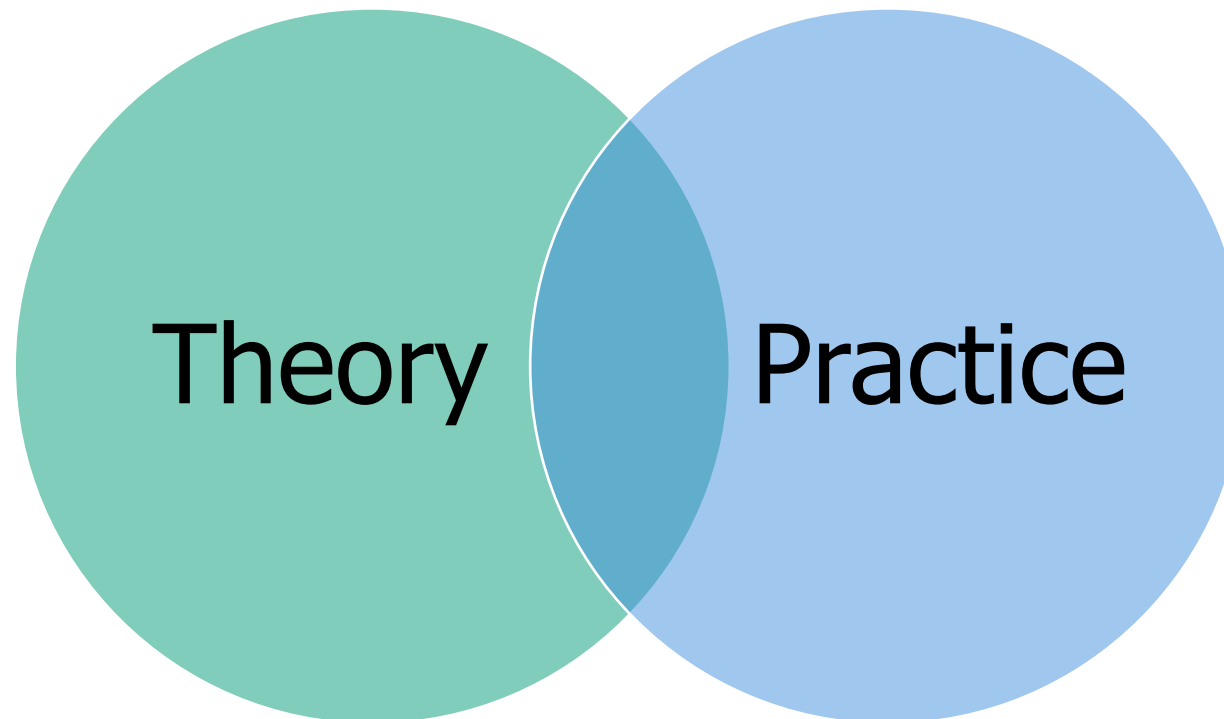
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# Lecture Schedule

# Lecture Schedule

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# Lecture Schedule

Introduction to Augmented Reality

Transformation, Parameter Estimation

Camera Models and Calibration

Visual System and Perception

Rendering

Head Mounted Displays

Input Devices

Sonification

User-Centered Design

Medical AR

Theory

Practice



# Lecture Schedule

Theory

Practice

Introduction to Augmented Reality

Camera Models and Calibration

Visual System and Perception

Rendering

Head Mounted Displays

Project

<https://hub.jhu.edu/2022/05/19/augmented-reality-class-demonstrations/>



# Lecture Schedule

#	Date	Topic	Assignment		Remarks
			Release	Due	
1	08/30 (Tue)	Course Logistics			
2	09/01 (Thu)	Introduction to Augmented Reality			
3	09/06 (Tue)	Transformations	1		Roll-a-ball
4	09/08 (Thu)	Parameter Estimation (Part 1)			
5	09/13 (Tue)	Parameter Estimation (Part 2)	2		Transformations, Parameter Estimation
6	09/15 (Thu)	Camera Models and Projection Matrices		1	
7	09/20 (Tue)	Camera Calibration	3		Camera Models and Camera Calibration
8	09/22 (Thu)	Hands-on Session 1 (Marker Tracking)	4		Marker Tracking
9	09/27 (Tue)	Visual System and Perception		2	
10	09/29 (Thu)	Hands-on Session 2 (Rendering)	5		Rendering, Visual Perception
11	10/04 (Tue)	Head-mounted Displays		3	
12	10/06 (Thu)	Hands-on Session 3 (HoloLens)			
13	10/11 (Tue)	Input Devices		4	
14	10/13 (Thu)	Other AR Modalities (Sonification)			
15	10/18 (Tue)	User-Centered Design (Guest Lecture)		5	
16	10/20 (Thu)	Medical Augmented Reality			
17	10/25 (Tue)	Mid-Term Exams			Mid-Term Exams

# Lecture Schedule

#	Date	Topic	Assignment		Remarks
			Release	Due	
18	10/27 (Thu)	Projects Introduction			
19	11/01 (Tue)	Project Development			
20	11/03 (Thu)	Project Development			
21	11/08 (Tue)	Kick off Presentation			
22	11/10 (Thu)	Project Development			
23	11/15 (Tue)	Project Development			
24	11/17 (Thu)	Project Development			
25	11/22 (Tue)	Project Development			Thanksgiving!
26	11/24 (Thu)	Project Development			Thanksgiving!
27	11/29 (Tue)	Project Development			
28	12/01 (Thu)	Project Development			
29	12/06 (Tue)	Project Development			
30	12/08 (Thu)	Project Development			Poster/Report Submission Deadline
31	12/13 (Tue)	Demo Preparation			
32	12/15 (Thu)	Final Presentation and Demo			Final Exam (Demo Day)





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# Assessment

# Assessment

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- Assignments (40%)
- Quizzes (5%)
- Midterm exam (15%)
- Final project (40%)

# Grade Breakdown

- Assignments (40%) -> (5 x 8%, with bonus, capped at 40%)
  - Introduction to augmented reality (8%)
  - Transformations and Parameter Estimation (8%)
  - Camera Models and Camera Calibration (8%)
  - Marker Tracking (8%)
  - Visual Perception and Rendering (8%)



# Grade Breakdown

- Quizzes - Exit Ticket (5%)
  - Contain topics discussed in the lectures (weekly / biweekly)
- Midterm exam (15%)
  - October 25<sup>th</sup> , 2022



# Grade Breakdown

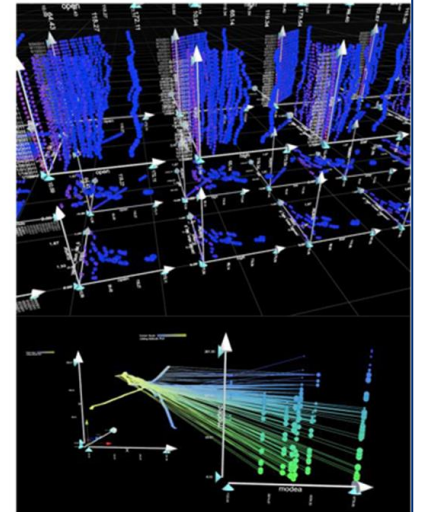
- Final project (40%)
  - 5% Kickoff presentation → November 8<sup>th</sup>, 2022
  - 20% Implementation → October 27<sup>th</sup>, 2022 - December 8<sup>th</sup>, 2022
  - 15% Poster and Demo → December 15<sup>th</sup>, 2022
    - Two pages report IEEE Conference Paper Format (10%)
    - Poster for presentation (5%)

# Final Projects, Examples

- Augmented Reality
  - Spring 2021
  - Prof. Nassir Navab
- Teaching / Education

## Immersive Visual Analytics of Data Analysis in Mixed Reality

- **Background:**
  - During user studies of VR/AR systems, data with complex relationships are acquired.
  - This project aims to create a platform for the visualization of such data in a MR environment.
- **Objective:**
  - Build a Visual Analysis Pipeline for Unity.
  - We have data available that can be provided to generate the visualizations.
- **Suggested Features to Use:**
  - Immersive Analytics Toolkit ([github.com/MaximeCordeil/IATK](https://github.com/MaximeCordeil/IATK))
  - Smartphones/Tablets and RGB cameras.



**ID: 04**



Computer Aided Medical Procedures

March 18, 2021 Slide 10

# Final Projects, Examples

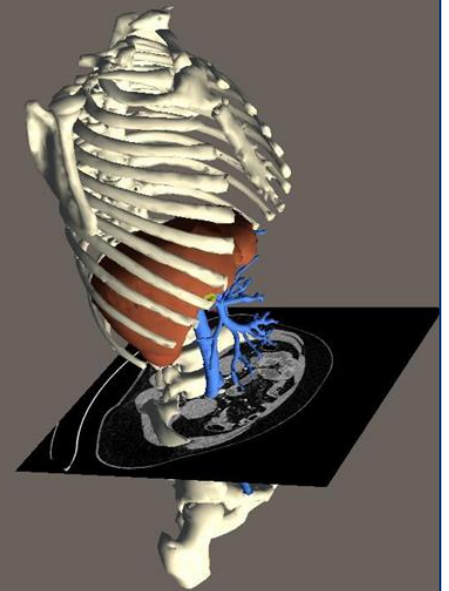
- Augmented Reality
  - Spring 2021
  - Prof. Nassir Navab
- Medical Applications

## A Serious Radiology Education Game

- Background
  - Radiology education constitutes only a minor component in today's undergraduate medical curricula.
  - Learning radiology has been shown to be beneficial in terms of students' 3D understanding when integrated into medical teaching as early as possible.
- Objectives:
  - Develop a serious game in which a target CT slice or X-ray projection is provided. The task focuses on correctly locating the target images either by moving a plane within a 3D model (for axial, sagittal, coronal, and potentially oblique CT slides).
- Suggested Features to use:
  - Smartphones or tablets and an RGB camera.
  - User Interaction (Grabbing slices and manipulating the slices)



Computer Aided Medical Procedures



ID: 07

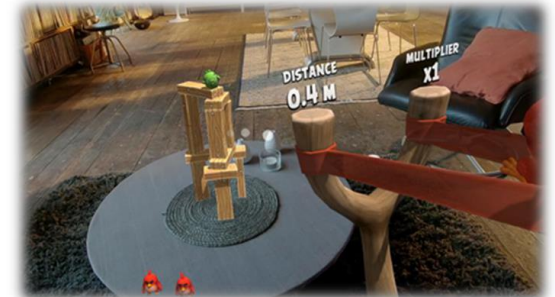
March 18, 2021 Slide 13

# Final Projects, Examples

- Augmented Reality
  - Spring 2021
  - Prof. Nassir Navab
- Gamming

## AR Angry Bird

- Objective:
  - Develop an AR “angry bird” like game
  - Find a flat surface in the environment and generate a base for bad piggy
  - Use a slingshot (with marker) to launch the birds and destroy their base
- Suggested Feature to Use:
  - Marker Tracking
  - Spatial mapping
- Milestones:
  - Make your own trackable slingshot
  - Find flat surface in environment and generate the base
  - More types of birds with different special power



**ID: 08**



Computer Aided Medical Procedures

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# Late Submissions



- Mark all deadlines in your calendar (assignments, mid-term exam, poster, and demos)
- Late submission are NOT accepted!!!
- Late submission results in 0 scores.





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# Communication Channels

# Grading and Communication Channels



■ Canvas



# Grading and Communication Channels



■ Canvas



■ Gradescope



■ Discord



■ GitHub Pages



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# Team Members

# Team Members

## Alejandro Martin Gomez

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Class Assistant

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# Other Related Topics

# Research and Final Projects

- If you are interested in conducting research and want to publish your project, please reach out to your mentors once the projects start (strongly encouraged).
- Projects from last semester has been now accepted to the Augmented Environments for Computer Assisted Interventions workshop and will be published at the Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization journal.

## Towards Reducing Visual Workload in Surgical Navigation: Proof-of-concept of an Augmented Reality Haptic Guidance System

Gesiren Zhang<sup>a,b</sup>, Jan Bartels<sup>a</sup>, Alejandro Martin-Gomez<sup>a,c</sup>, Mehran Armand<sup>a,b,c,d</sup>

<sup>a</sup>Biomechanical- and Image-Guided Surgical Systems (BIGSS) Lab, Laboratory for Computational Sensing and Robotics, Johns Hopkins University, Baltimore, MD, USA

<sup>b</sup>Department of Mechanical Engineering, Johns Hopkins University, Baltimore, MD, USA

<sup>c</sup>Department of Computer Science, Johns Hopkins University, Baltimore, MD, USA

<sup>d</sup>Department of Orthopaedic Surgery, Johns Hopkins University, Baltimore, MD, USA

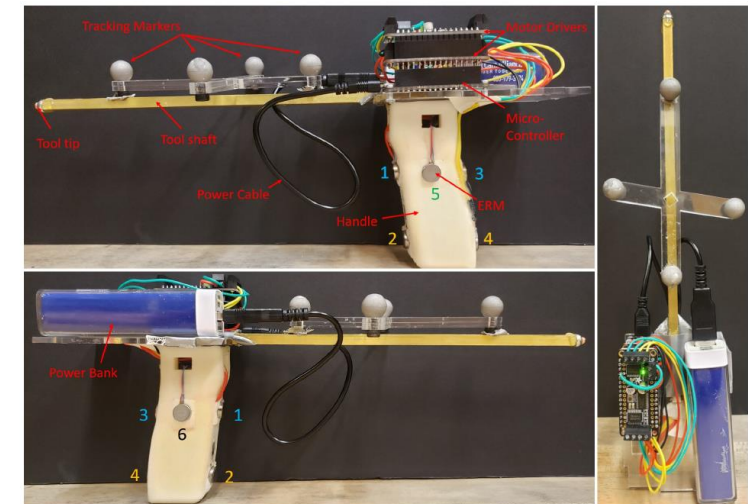


Figure 1.: The custom mock surgical tool consisted of 6 ERMs on the handle; tool shaft and tip; a set of tracking markers; motor drivers and controller; and a power bank connected to the controller via a power cable.

# Waitlist

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- If you are on the waitlist and need to access the materials before being able to register for the class, please contact Irene Kim, (our leading TA)
- The course was originally designed for 30 students.
- The capacity has been increased it to the maximum number of spaces available at Maryland 310



# Software



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# Unity 3D



[Learn Unity](#) [Teach Unity](#) [Bring Unity into your classroom](#) [Access free learning](#)

## Learn Unity

Build your project, learn a new skill, refresh your knowledge, change careers – whatever your goal, get started here.

A person wearing headphones looking at a computer screen displaying a game development interface.

### Online learning

Free tutorials, projects, and courses

Visit Unity Learn for free, on-demand learning content designed for creators at every skill level.

[Start learning](#)

A student wearing headphones working on a laptop in a classroom setting.

### Student plan

Free Unity license for students

Kickstart your learning with free access to Unity Pro, perfect for studying in the classroom or practicing at home.

[Get started](#)

Hands typing on a laptop keyboard with multiple monitors in the background.

### Certifications

Prove your Unity skills

Test your Unity knowledge and showcase your abilities to future employers with our range of certification exams.

[Get certified](#)

Two people, a woman and a man, looking at a laptop screen together.

### Professional Training

Enhance your team's skills with Professional Training

Increase productivity and improve workflows with training courses led by Unity Certified Instructors, designed for professionals in any industry.

[Start training](#)

<https://unity.com/learn>

<https://learn.unity.com/>

# Install Unity HUB

A screenshot of the Unity website's download page. The page has a dark header with the Unity logo and navigation links: Products, Solutions, Case Studies, Learning, Asset Store, and Support & Services. The main content area is white and divided into two columns. The left column has a large heading "Download Unity", a welcome message, a link to learn more about the new Unity Hub, two green buttons ("Choose your Unity + download" and "Download Unity Hub"), a heading "Download Unity Beta", a message about early access, a blue "Download Beta" button, and a heading "Already a customer?". The right column has a heading "System requirements", a "Learn more" button, a heading "Releases", and a list of links for Long Term Support (LTS) releases, a tech stream, and pre-release technology. Below that is a heading "Resources" with links for Documentation, Knowledge Base, and Support.

**Download Unity**

Welcome! You're here because you want to download Unity, the world's most popular development platform for creating 2D and 3D multiplatform games and interactive experiences.

Before you download choose the version of Unity that's right for you.

[Choose your Unity + download](#) [Download Unity Hub](#)

[Learn more about the new Unity Hub here.](#)

**Download Unity Beta**

Get early access to our latest features, and help us improve quality by providing valuable feedback.

[Download Beta](#)

**Already a customer?**

Awesome. Download Unity here if you have a Plus or Pro subscription.

**System requirements**

**OS:** Windows 7 SP1+, 8, 10, 64-bit versions only; Mac OS X 10.12+; Ubuntu 16.04, 18.04, and CentOS 7.

**GPU:** Graphics card with DX10 (shader model 4.0) capabilities.

[Learn more](#)

**Releases**

- [Long Term Support \(LTS\) releases](#)
- [Learn about Unity 2020 LTS + Unity 2021.1 Tech Stream](#)
- [Pre-release technology](#)

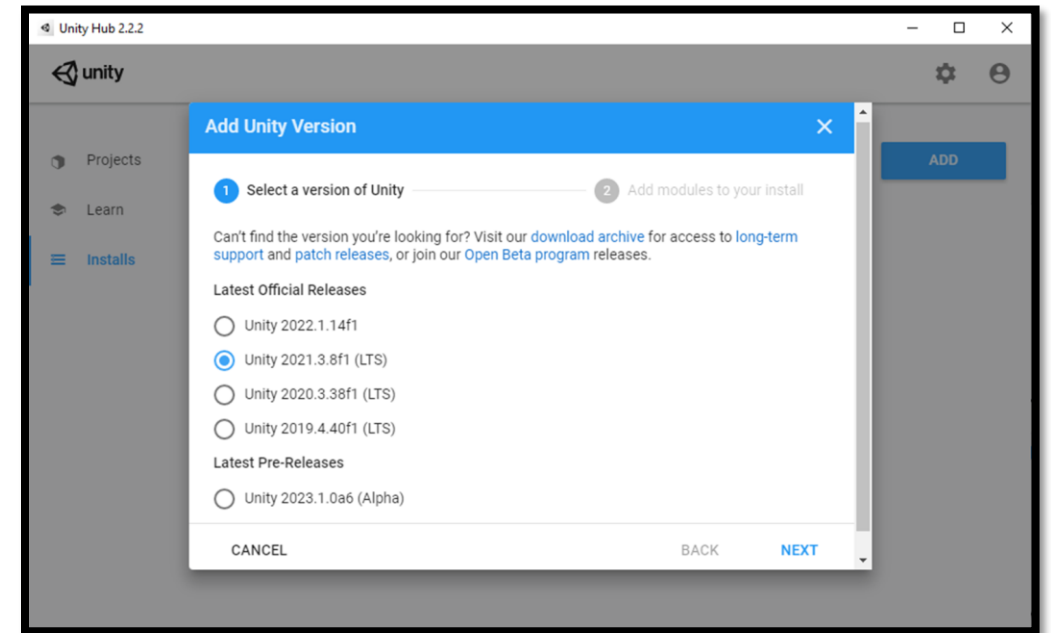
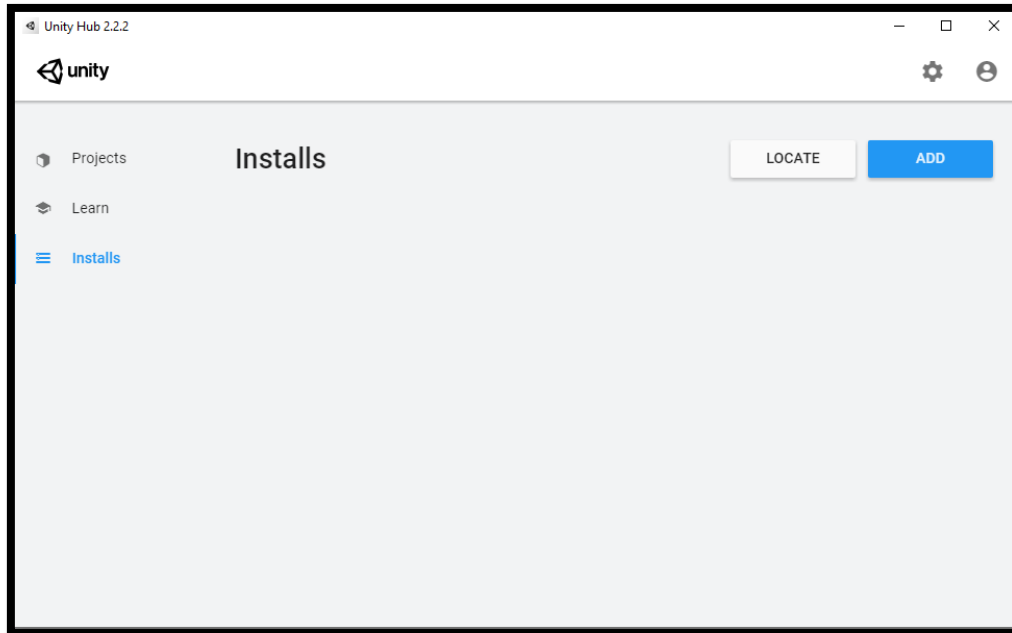
**Resources**

- [Documentation](#)
- [Knowledge Base](#)
- [Support](#)

<https://unity3d.com/get-unity/download>

# Install Unity 2021.3.8f1 (LTS)

- This will be important for all our exercises and hands-on sessions







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# Questions?





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