

# Extended Reality

Dr Fangcheng Zhong



# Course Format

- 12 + 4 hours
  - guest lectures from industry experts
- One practical exercise (20%)
- One course project (80%)
  - a video-based AR application
  - in groups of 2 persons
  - more information on Moodle

# Contributors

- Lecturer
  - Dr. Fangcheng Zhong
- Principal lecturer
  - Prof. Cengiz Oztireli
- Teaching assistants
  - Zhilin Guo (zg296)
  - Kyle Fogarty (ktf25)

# Prerequisite

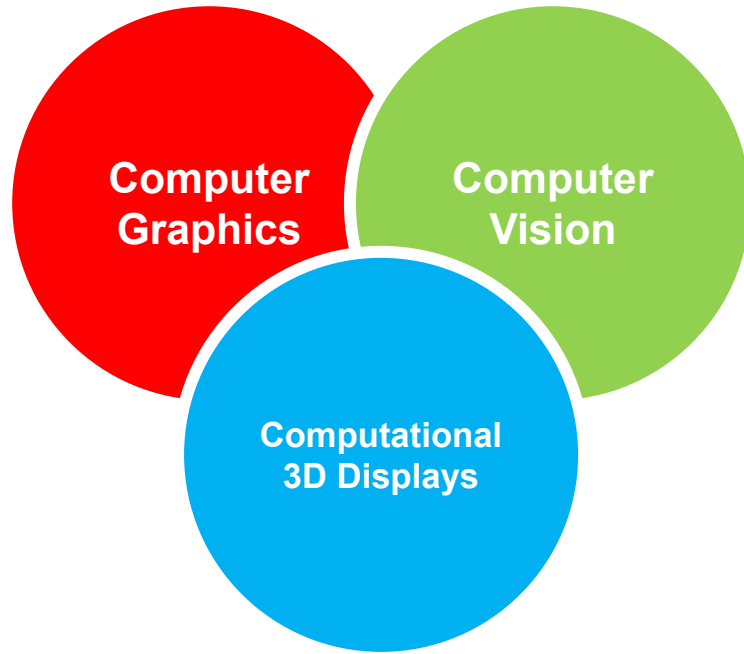
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- Intro + further graphics
- No prior knowledge about computer vision or 3D displays is needed

# Outline

- Course logistics
- What is XR?
  - definition, applications, advancement
- XR pipeline
- XR frameworks

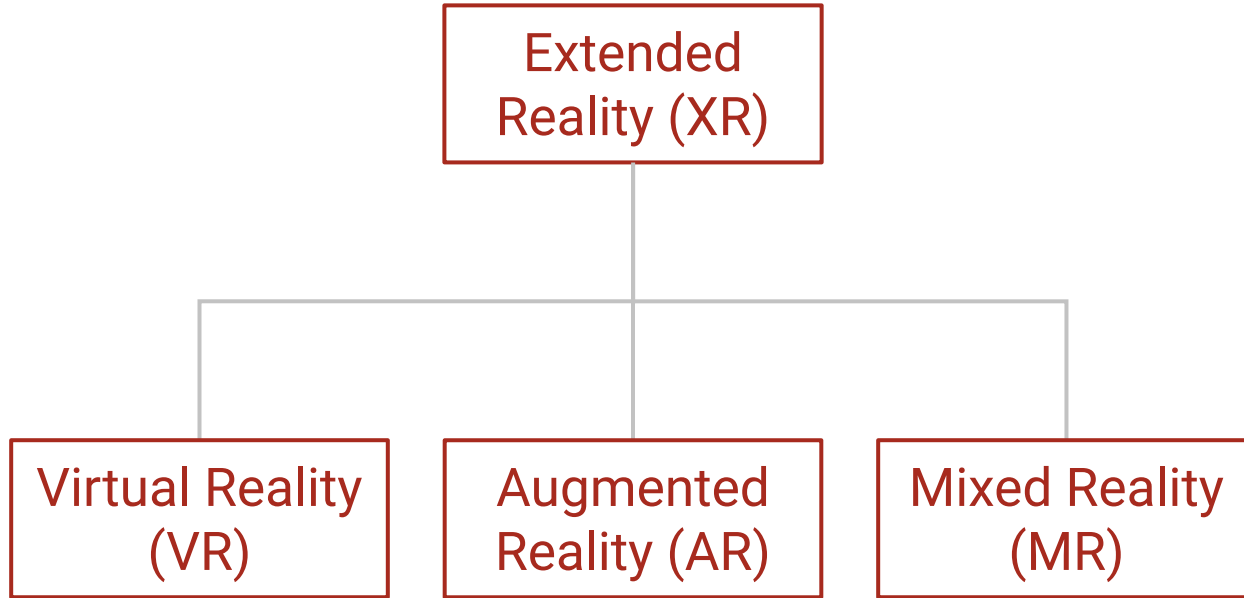
# Extended Reality (XR)



## Goal

**Immersive, realistic, and interactive** digital experiences blending the physical and digital worlds

# XR Terminologies



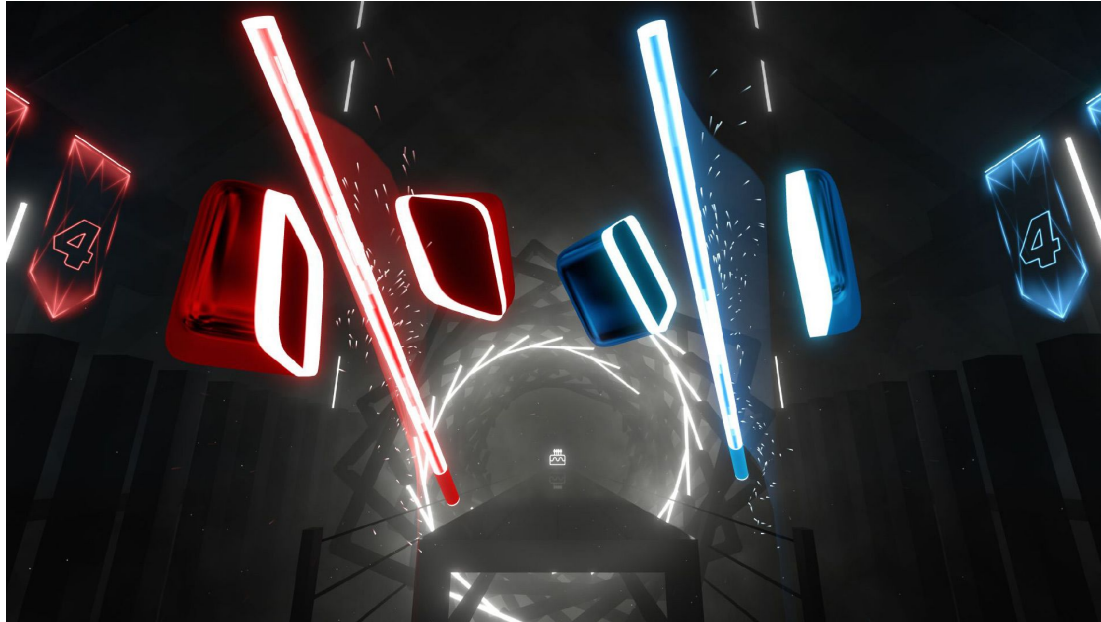


**Virtual Reality** creates a digital environment that replaces the physical environment





# Virtual Reality (VR)



**gaming**

# Virtual Reality (VR)



flight simulator

# Virtual Reality (VR)



**virtual field trip**

# Virtual Reality (VR)



**visualisation, 3D modeling, and design**

# Virtual Reality (VR)



**HTC VIVE**



**Meta Quest**



**Sony Playstation**



**Valve Index**



**Augmented Reality** overlays  
digitally created content into the  
physical environment

Gear 7-38 1:2.75

s/n: 3941501  
MT-450919  
Teeth: 40

Trans.Gear 13.25

s/n: 3941501  
MT-450919

STATOR (s3x51n)

s/n: 3941501  
MT-450919  
Op: 110-150  
Winding F: 0.99  
n.c. 24

Prototype Phase

Advanced Motor

Power

Torque

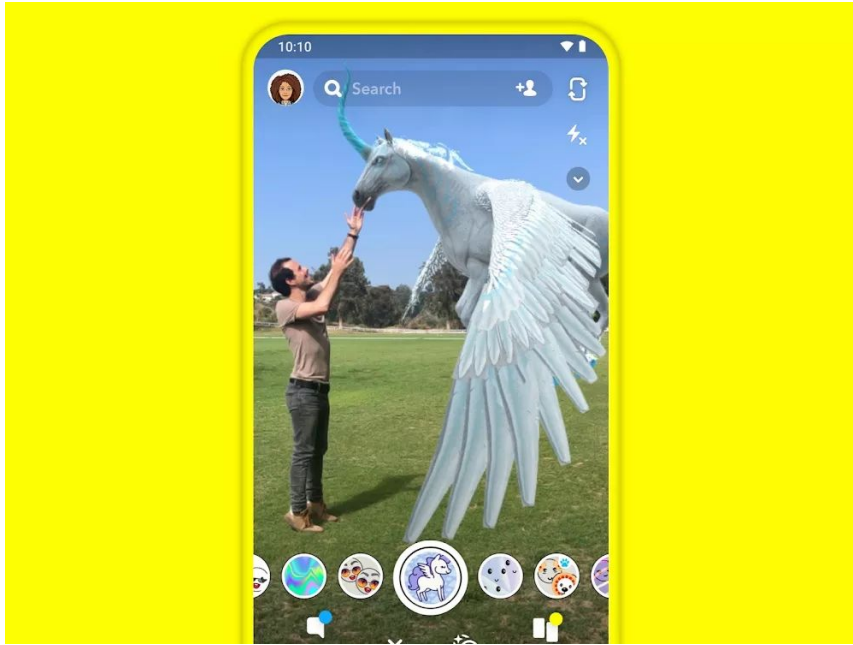
# Augmented Reality (AR)



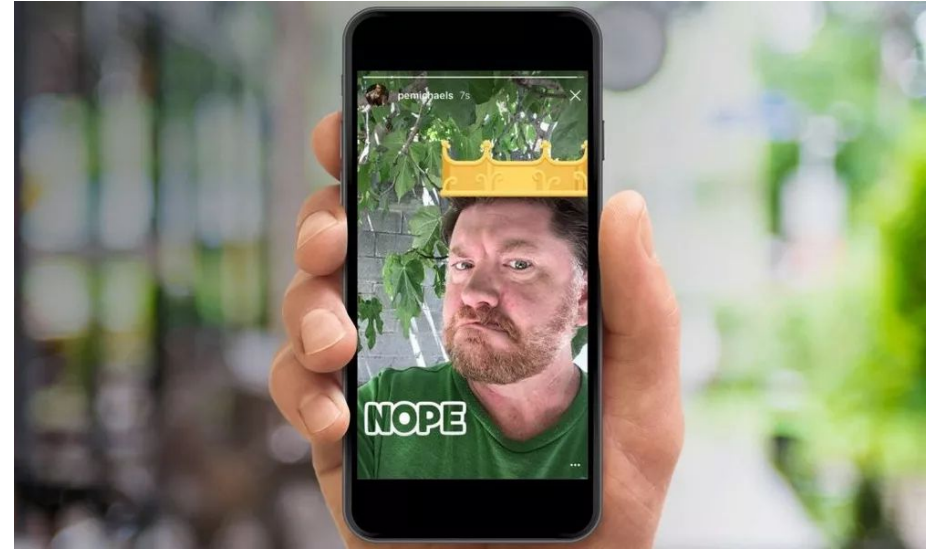
**Pokemon Go**



# Augmented Reality (AR)



Snapchat



Instagram

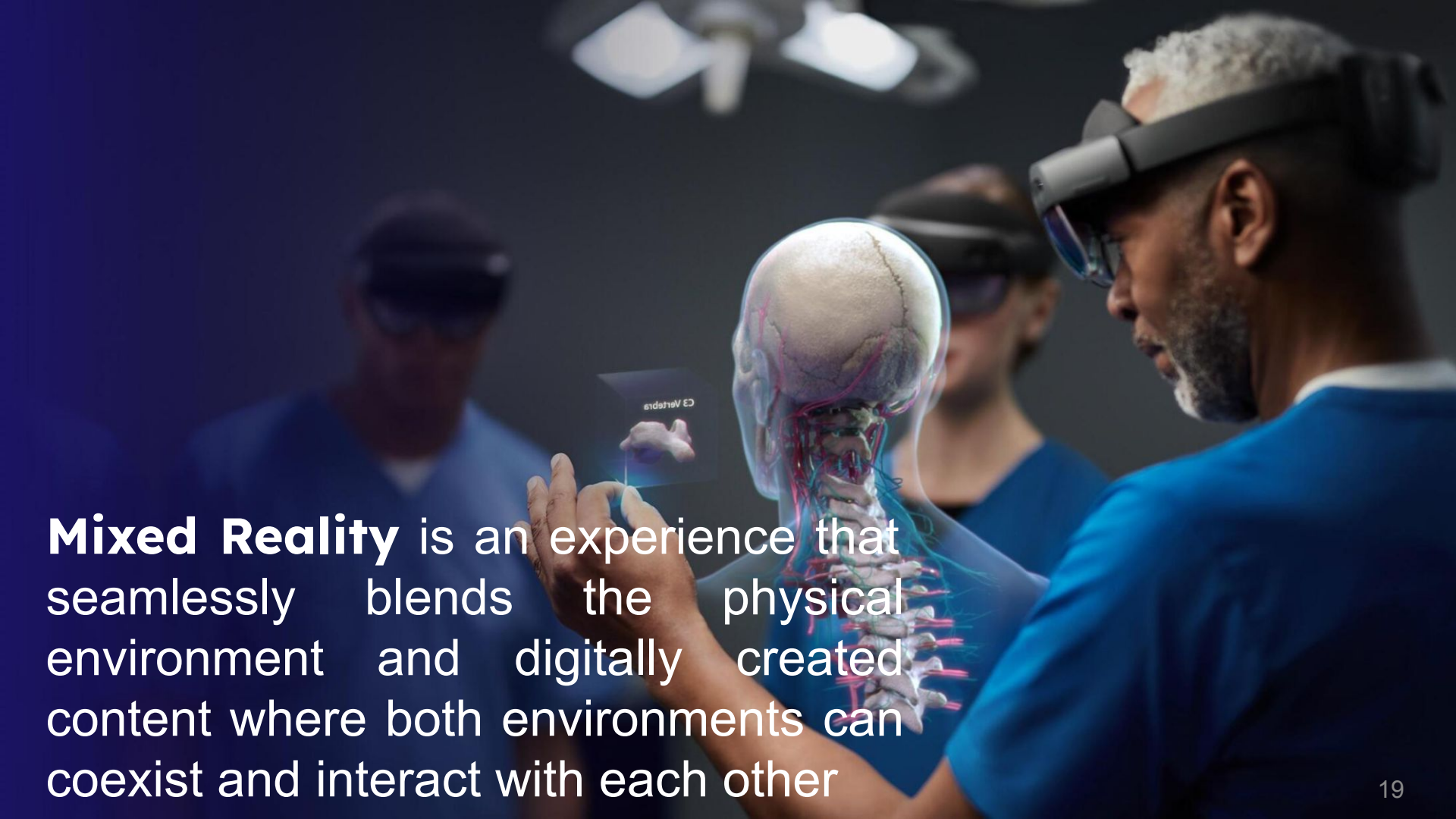
# Augmented Reality (AR)



IKEA Place



Google Translate



**Mixed Reality** is an experience that seamlessly blends the physical environment and digitally created content where both environments can coexist and interact with each other



# Mixed Reality (MR)

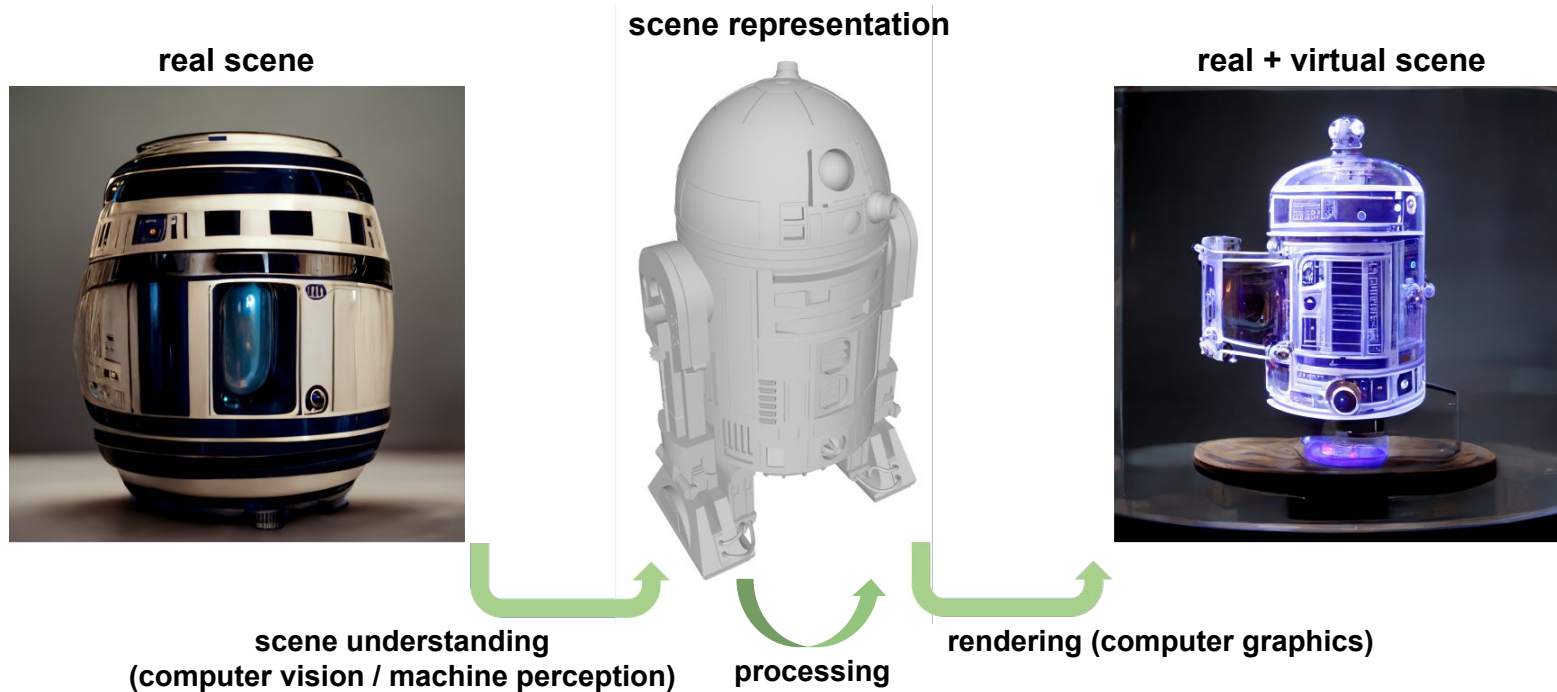


**HoloLens**



**Magic Leap**

# XR Pipeline



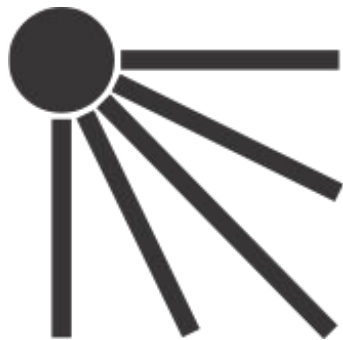
# XR Pipeline

- Same pipeline for VR, AR, and MR
- Only differs in capture and display devices!

# Scene representations



**Geometry**



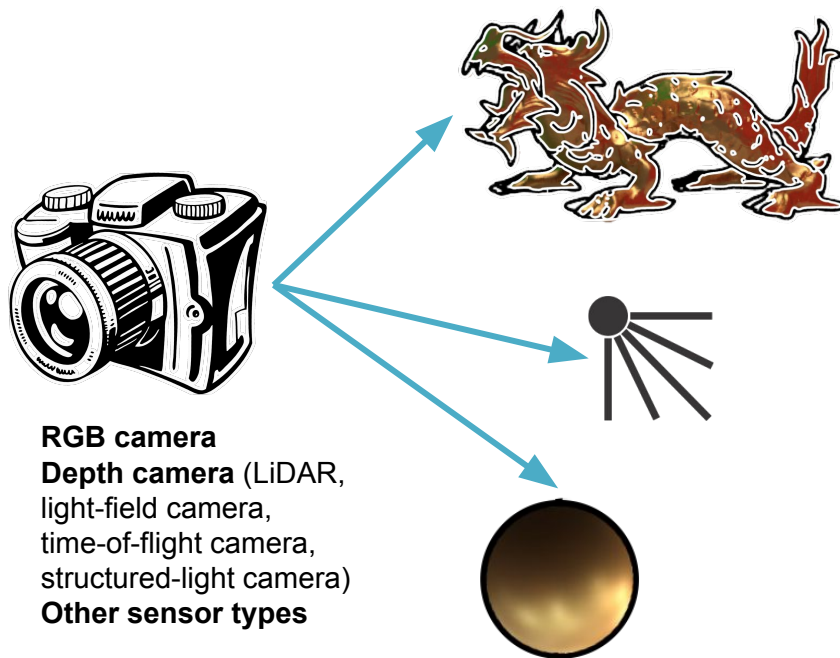
**Lighting**



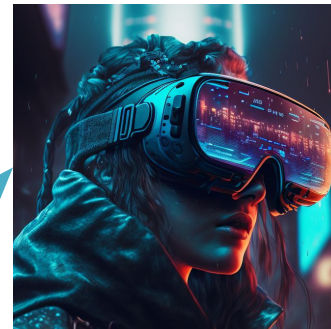
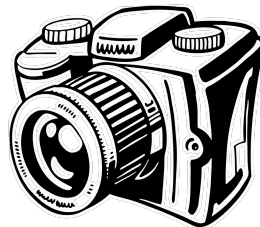
**Materials**



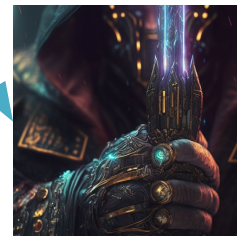
# Machine Perception



# Machine Perception

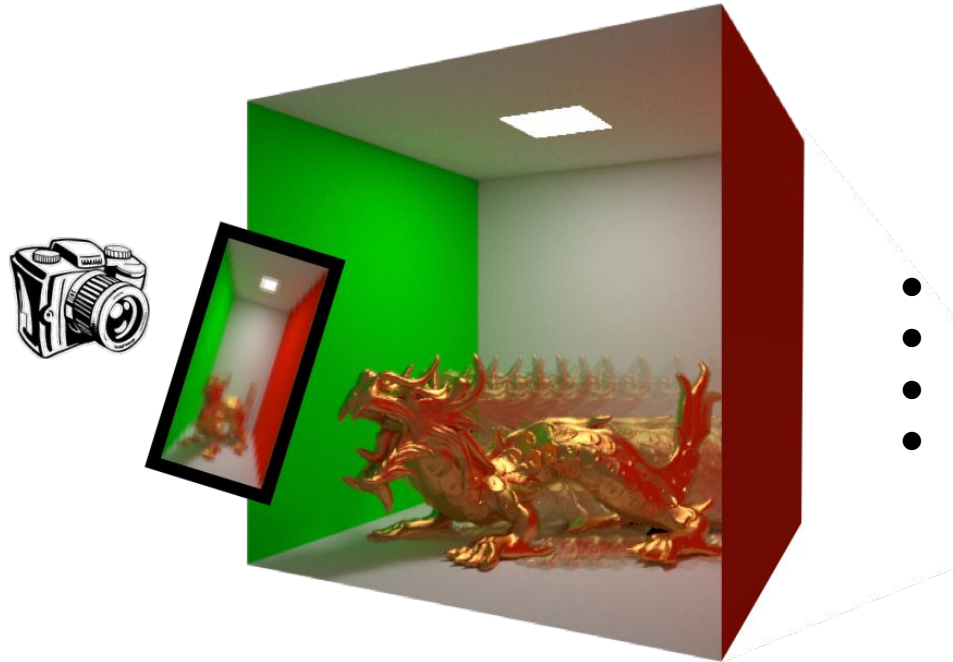


Head pose



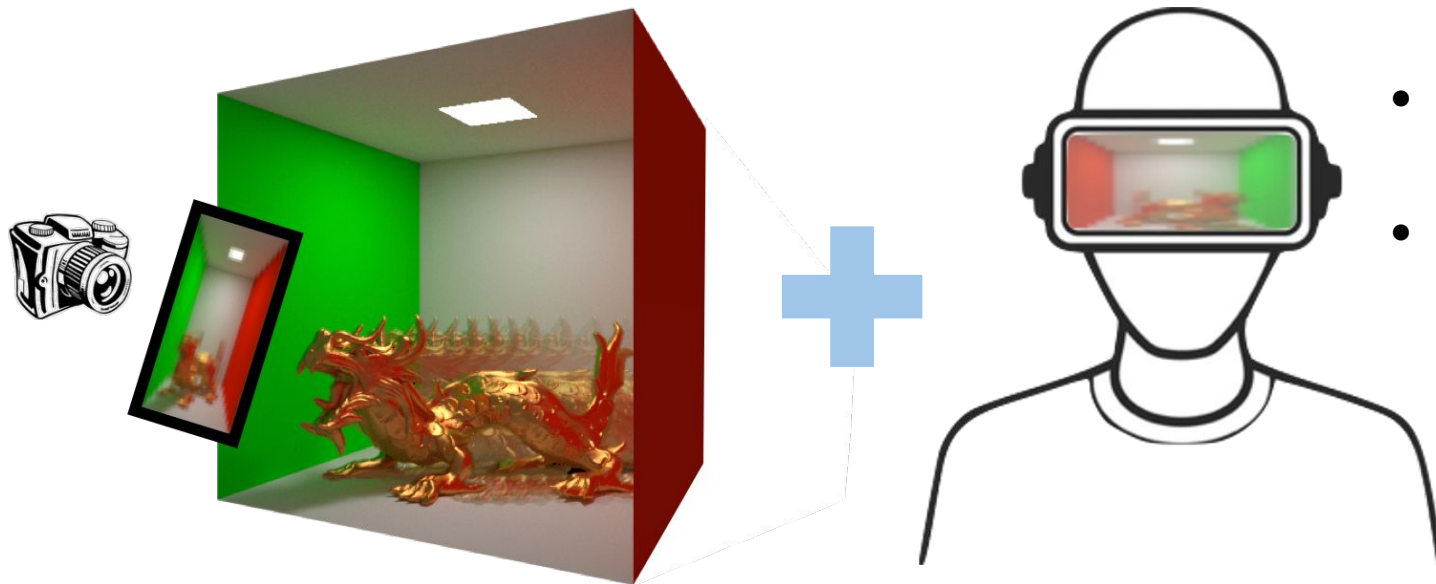
Hand pose

# Processing



- **User Interaction**
- **Physics**
- **Animation**
- **Relighting**

# Rendering + 3D Display



- Stereo rendering
- Foveated rendering
- Advanced 3D display rendering

- **Stereo displays**  
(multi-focal display, vari-focal display)
- **Volumetric displays**  
(holographic display, light-field display, voxel-based display)

# XR @ Rainbow Lab



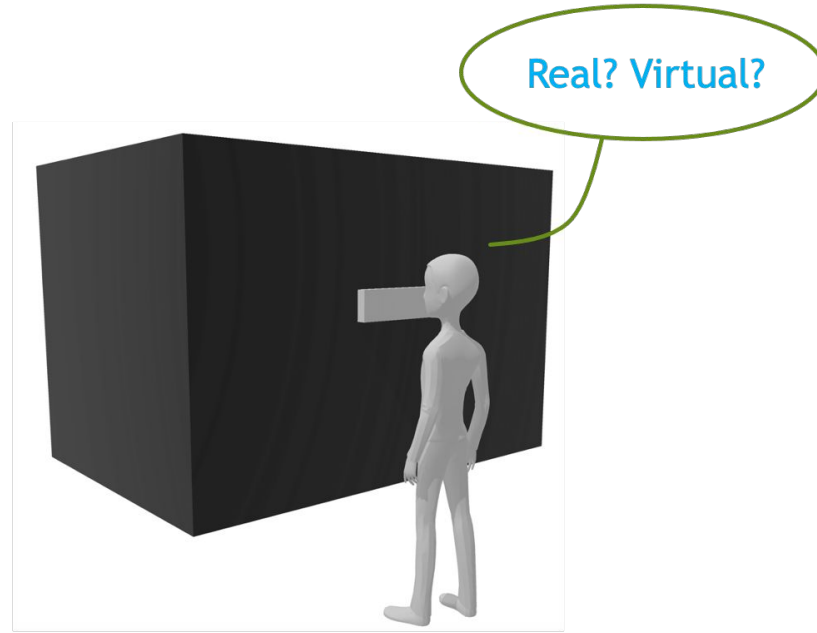
**Cambridge autostereo display project**

# XR @ Rainbow Lab



**Driving simulator, eye tracking, motion tracking**

# XR @ Rainbow Lab



Visual Turing Test Project

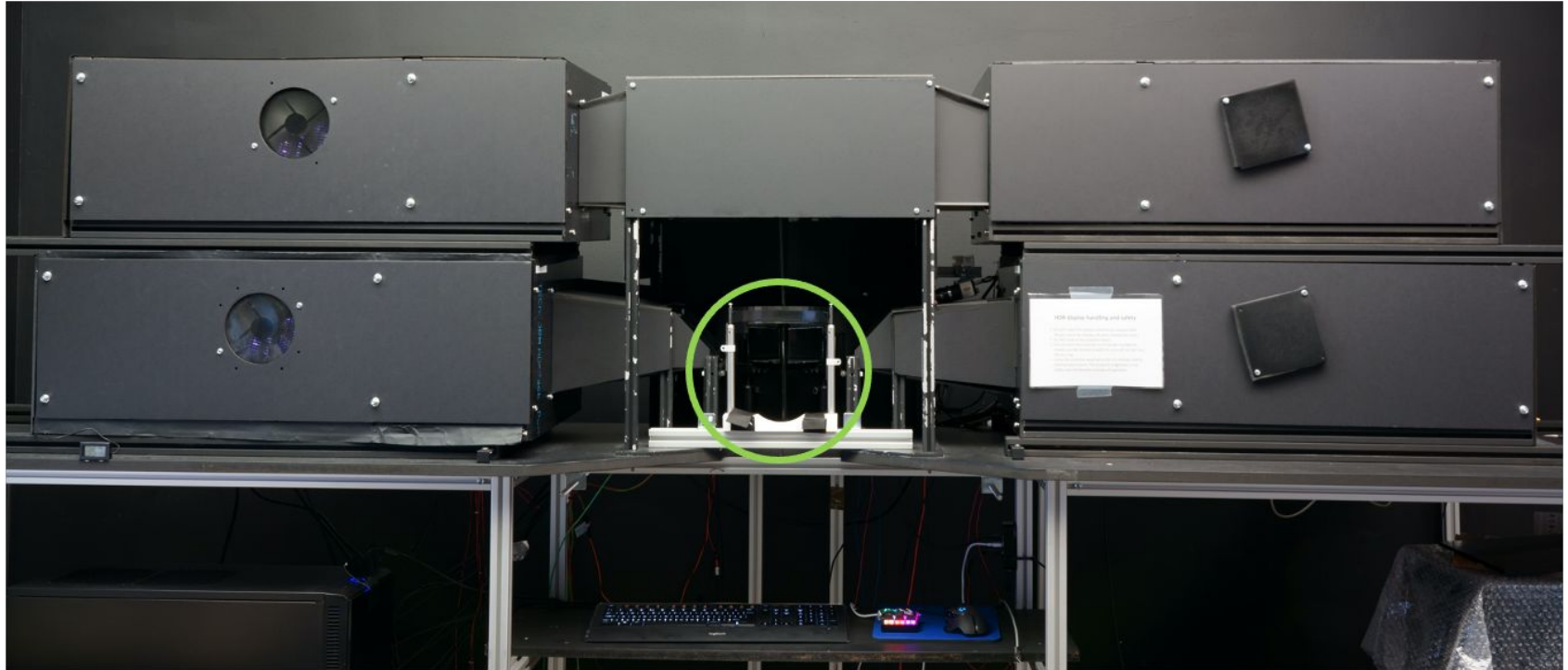
# XR @ Rainbow Lab



**High-dynamic-range multi-focal stereo display**



# XR @ Rainbow Lab





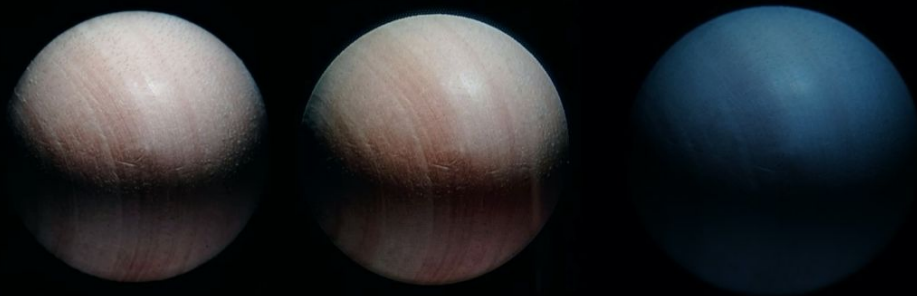
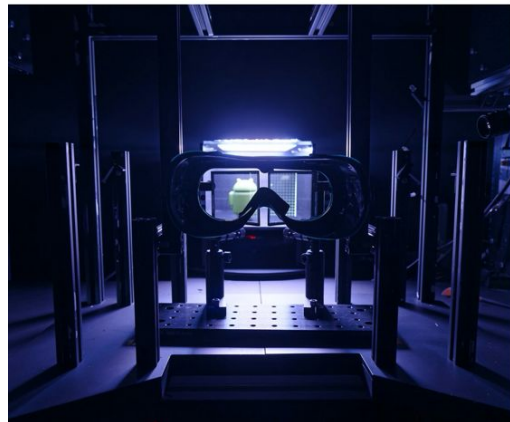
- Real-scene box

- Virtual scene



- Capture data from real-scene box

Which one is real?



# XR Frameworks

## ARCore ARCore

- a software development kit (SDK) developed by Google to build AR applications
- available on Android Studio, Unity, and Unreal engine for application development
- supported by a limited number of Android devices
- uses OpenGL and Vulkan for rendering

# XR Frameworks

## ARKit



- a software development kit (SDK) developed by Apple to build AR applications
- available on Xcode, Unity, and Unreal engines for application development
- supported by all iOS devices with an A9 or later chip
- uses Metal for rendering

# XR Frameworks

## AR Foundation

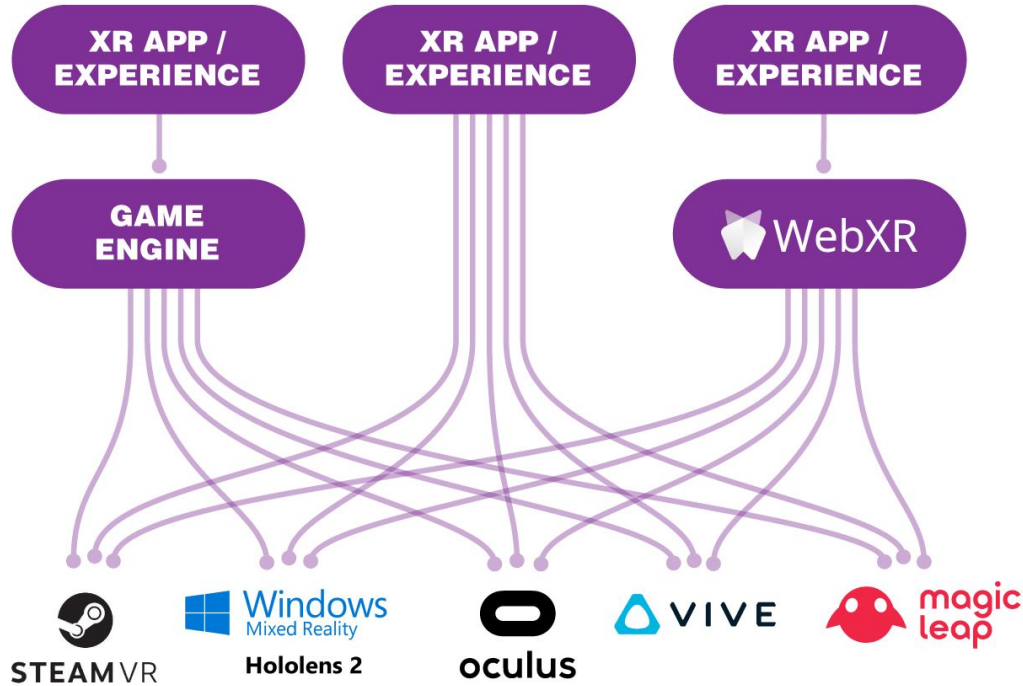
- a set of Unity packages that provide a common foundation for building AR applications for both Android and iOS devices
- support for the ARCore and ARKit SDKs, and allows developers to build AR applications that can run on either platform using a single codebase
- includes core features from ARKit, ARCore, Magic Leap, and HoloLens

# XR Frameworks

Device	Framework	Development Environment
HTC, Valve	steamVR	Visual Studio, Unity, Unreal Engine
Oculus, Meta	Oculus Mobile SDK	Visual Studio, Unity, Unreal Engine
Sony PlayStation	PlayStation SDK	PlayStation development kit
HoloLens	HoloLens 2 Development Edition	HoloLens 2 Development Kit, Visual Studio, Unity, Unreal Engine
Magic Leap	Magic Leap SDK	Visual Studio, Unity, Unreal Engine
Android	ARCore	Android Studio, Unity, Unreal Engine
iOS	ARKit	Xcode, Unity, Unreal Engine



# XR Frameworks

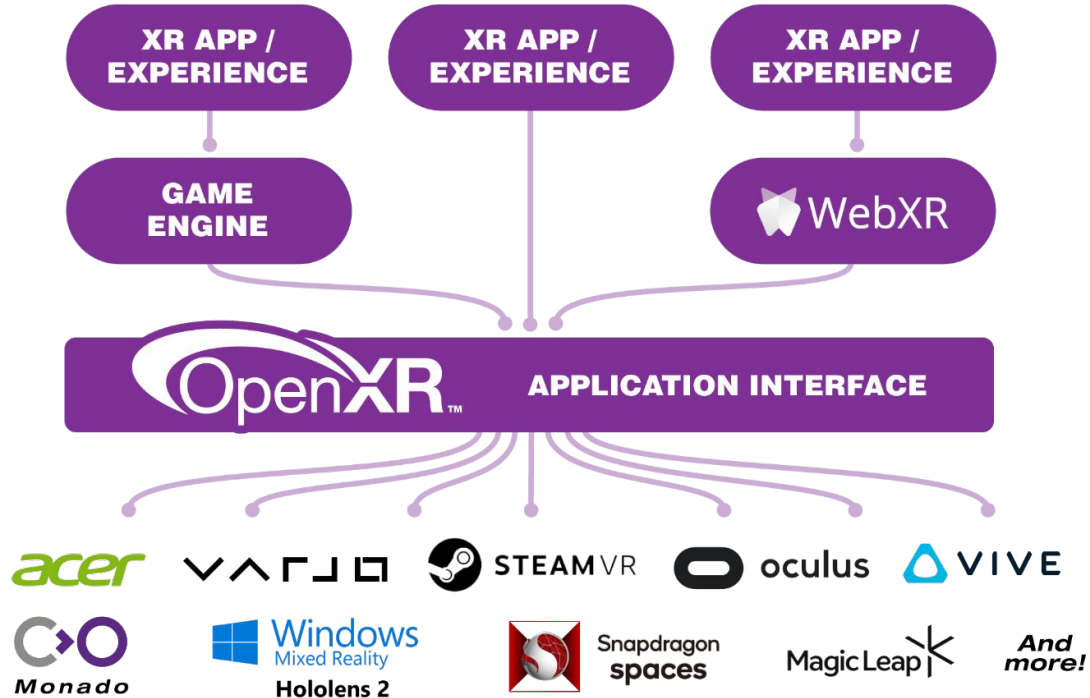


# XR Frameworks

## OpenXR

- open, royalty-free standard for accessing VR and AR systems
- a single, unified API to develop cross-platform applications
- developed by the Khronos Group, an industry consortium that also develops other graphics-related standards such as OpenGL and Vulkan

# XR Frameworks



# Practical Exercise

- Main tasks
  - camera pose estimation
  - AR Foundation device tracking
  - individual work
- Due 24 February 2023, 12:00 PM

# Course Project

- Main tasks
  - a video-based AR application
  - development using Unity AR Foundation
  - group work
- Deliverables
  - project plan
  - implementation
  - project report
  - presentation/demo

# Course Project

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- Timeline
  - Project proposal due 3rd February 2023, 12:00PM
  - Final report due 16 March 2023, 12:00 PM