# Lecture 2: Introduction to Extended Reality Hardware and Software

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# Key Information

- **Google classroom link:** https://classroom.google.com/c/NzkxMzY2MDQyNDgw?cjc=egnlvkyb
- **Class code:** egnlvkyb
- **Instructor:** Dr. Kalpana Shankhwar
- **Email id:** kalpana@iiitd.ac.in
- **Office:** A-403 (R&D Block)
- **Office hours:** Monday 1:30-3:30 pm
- **Class:** Monday and Thursday 11:00-12:30 pm

# Grading Policy

| Type of Evaluation | % Contribution in Grade |
|---|---|
| | |
| Class exercise | 10 [participation in class activities] |
| Assignment | 30 [4 Assignments] |
| Final project (group/individual) | 20 [1 or 2 individuals] |
| Mid term | 15 |
| End term | 25 |

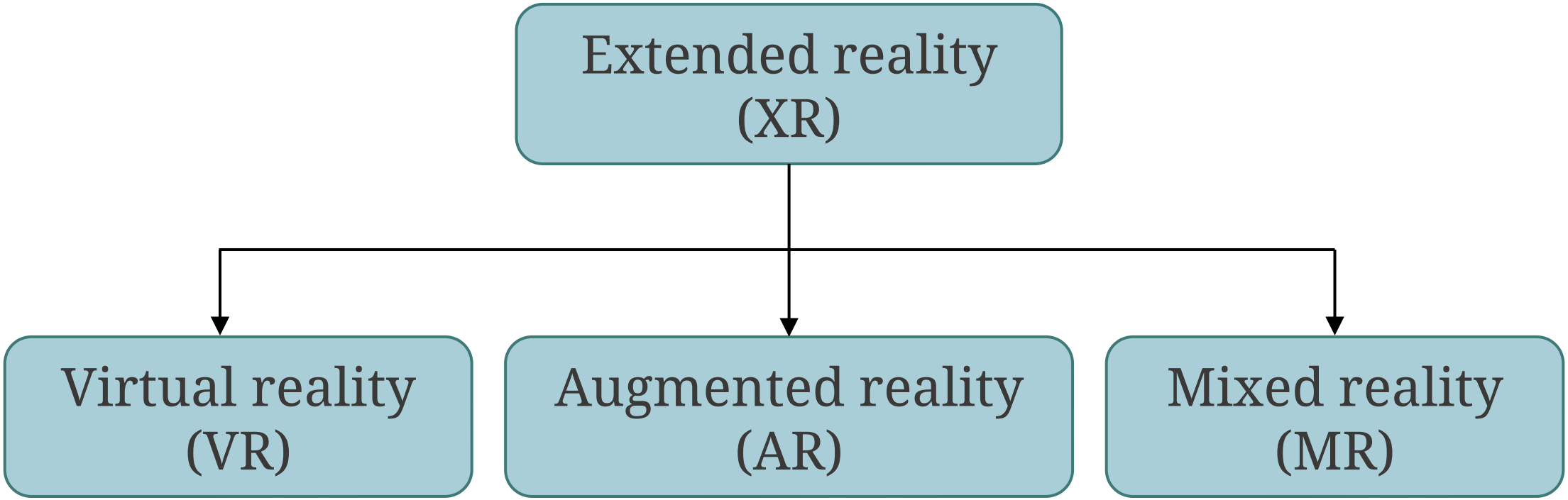
# Resources

- CAD/CAM Theory and Practice (by Ibrahim Zeid and R. Sivasubramaniam)
- S.N. Lal, Engineering Drawing with an Introduction to AutoCAD, Cengage India Private Limited, 1st Edition, 2017.
- Computer Aided Design: A Conceptual Approach (By Jayanta Sarkar)

| Week Number | Lecture Topic | Assignment/Labs/Tutorial/ Demonstration |
|---|---|---|
| Week 01 | Historical overview, current trends and future applications of extended reality (XR) technologies | |
| | Introduction to XR, hardware and software, importance of XR in Industry 4.0, types of game engine tools for building XR applications. | |
| Week 02 | Introduction to 3D creation, design and modelling theory, importance of 3D modeling processes in XR applications | |
| | Engineering drawing basics, types of perspectives, basics of computer graphics | |
| Week 03 | Basics of 3D modeling software and interface, 3D modeling of objects | Assignment/In-class exercise |
| Week 04 | Introduction to Game Engine tools for building XR applications, importing 3D models to Game Engine platform | In-class exercise |
| Week 05 | User interface elements in the Game Engine | Assignment/In-class exercise |
| Week 06 | Introduction to tracking for augmented reality (AR), types of tracking methods, Vuforia Engine for AR. | |
| Week 07 | Building an Anroid/iOS AR App. | Assignment/In-class exercise |
| Week 08 | Particle systems, application of 3D modeling in particle systems | |
| Week 09 | Haptic technology, visuo-haptic extended reality | Assignment/In-class exercise |

# Examples for assignment and final project


Score: 84

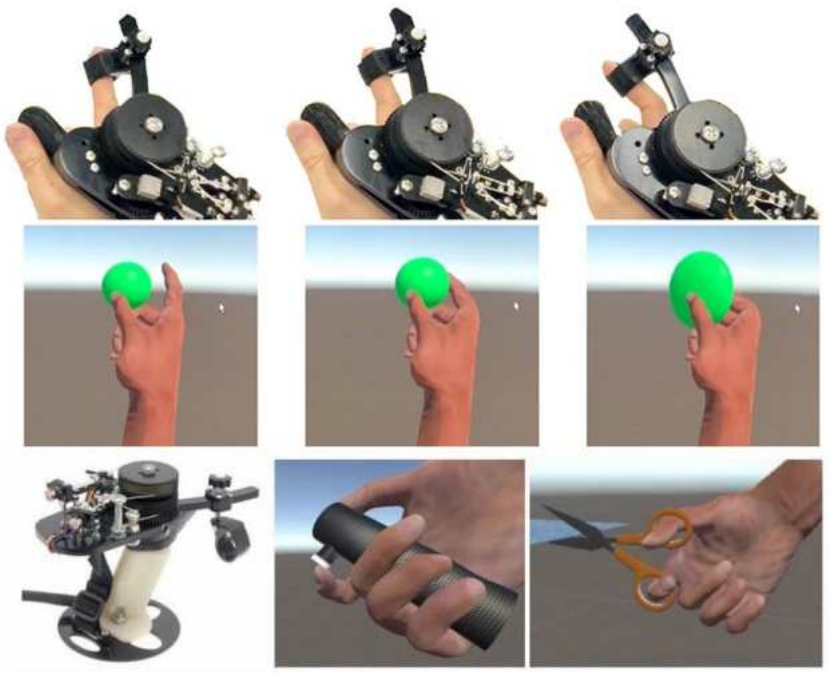

Extended reality
(XR)
Virtual reality
(VR)
Augmented reality
(AR)
Mixed reality
(MR)

# Haptics

Haptic technology is an integral part of XR, which
the sensation of touch by applying forces, vibratio
motion to make the XR environment realistic and
immersive by enabling users to touch the digital
information.

There are two types of haptic feedback:

1. Kinesthetic
2. Tactile



A haptic VR controller

# Kinesthetic feedback

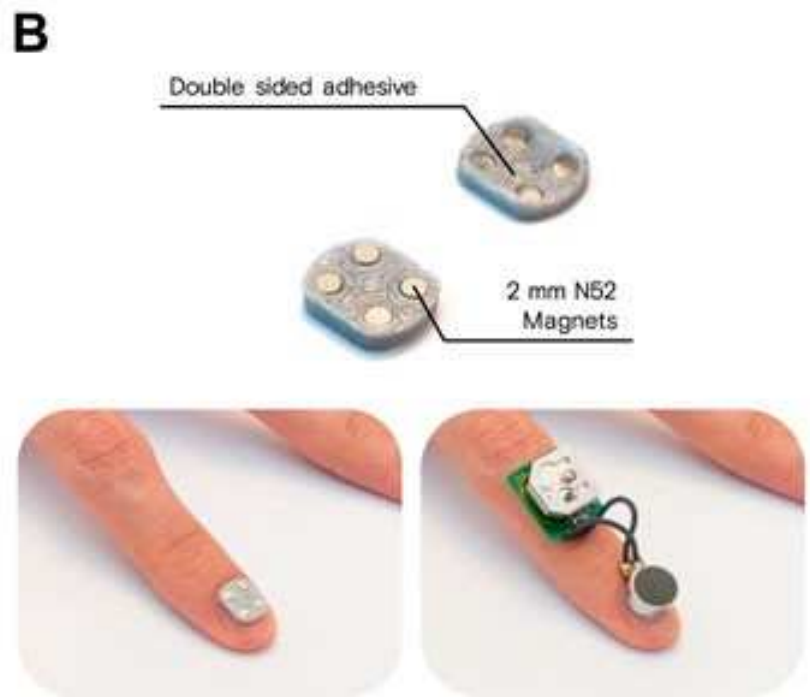
- Kinesthetic feedback enables the user to perceive the size and density of an object through physical sensation, primarily from muscles and joints.
- Kinesthetic devices simulate the force and torque to the user through tools such as linear actuator or electric motor to enable the user's interaction in the virtual environment.

# Kinesthetic feedback

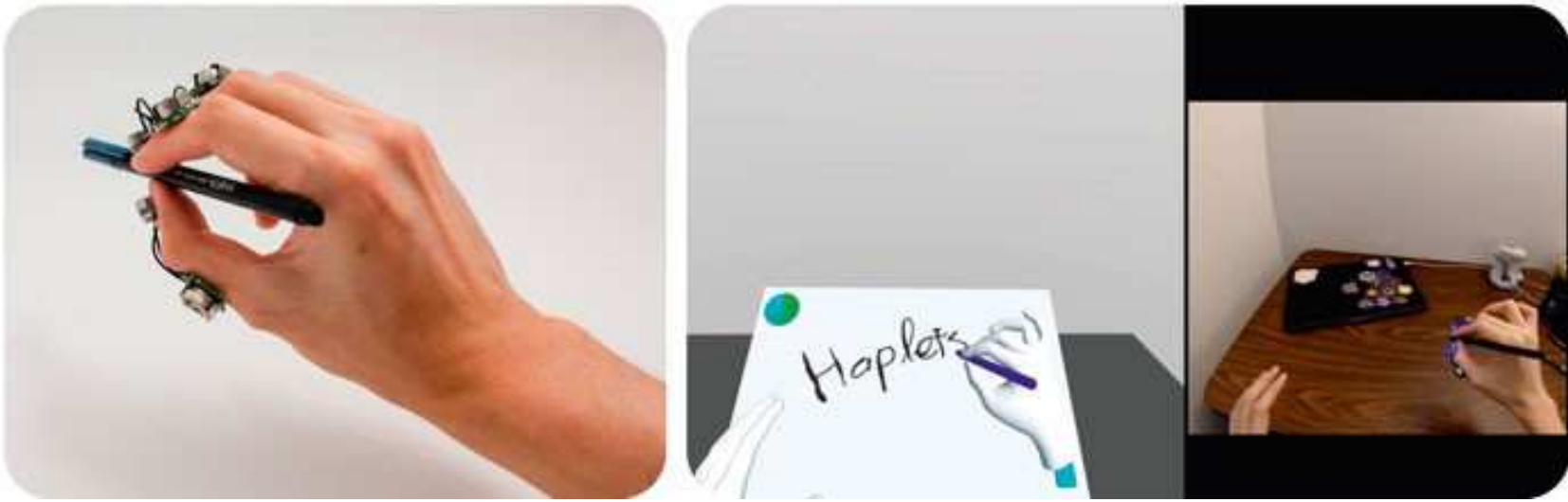
# Tactile feedback

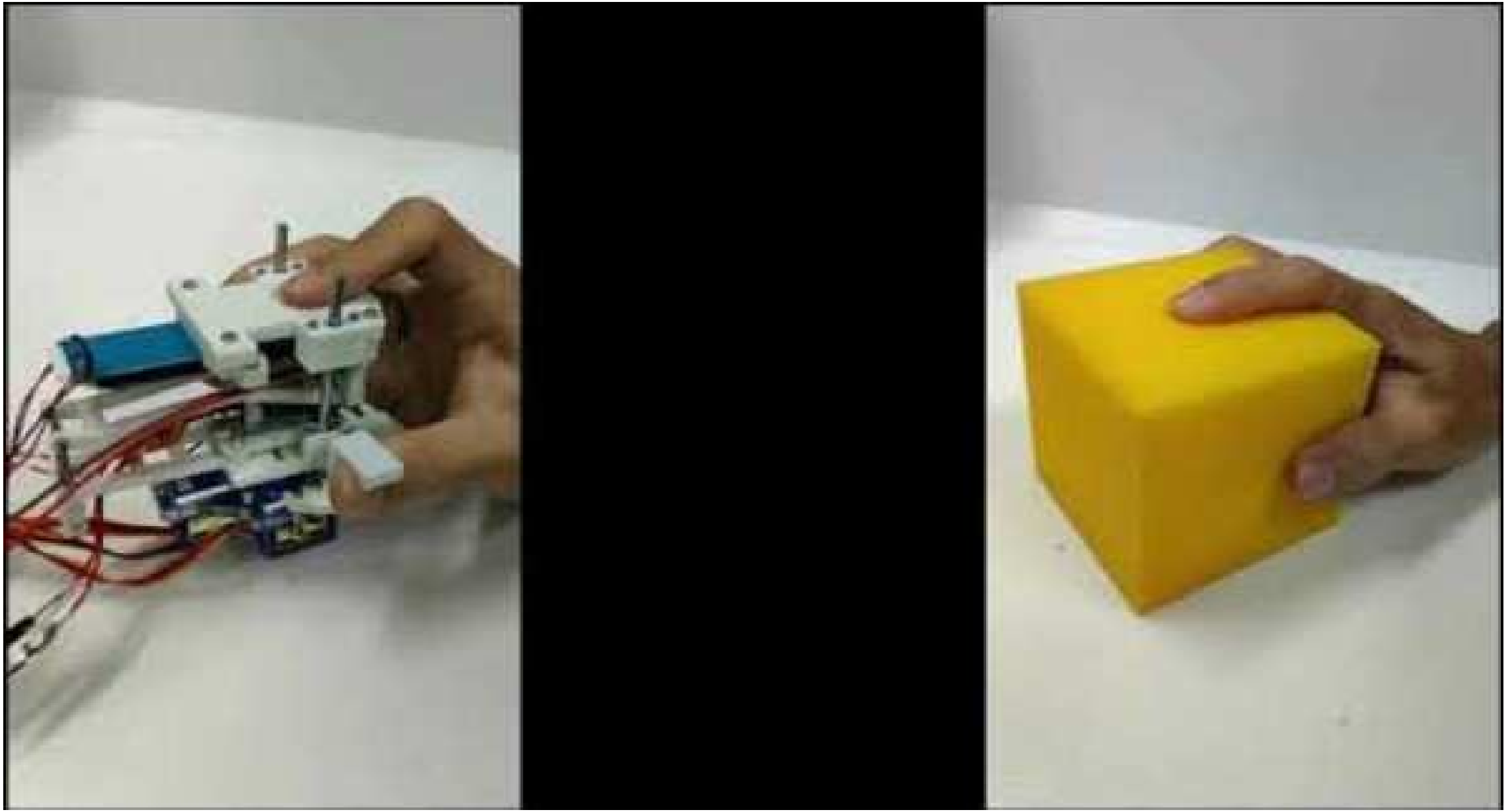
- Tactile feedback typically refers to the sense of touch or the physical contact between a user and a device.
- Tactile sensation deals with information about physical surface such as contact force, geometry of object and temperature.
- It involves the sense of touch to transmit information and communicate with the user, such as a mobile phone vibration. It is primarily sensed through skin. Tactile feedback can include vibrations, temperature changes, and pressure sensations.
- Tactile devices distributes the tactile forces over the region of contact and simulate that contact to the skin.


A
G1040003D
10 mm LRA
CP1254
Lithium-ion Battery
H: 5.5 mm
nRF52832
Wireless SoC
L: 16.6 mm
W: 13.7 mm
Reset Button
LED
3.3V Regulator
DFU Button
DRV8838
Motor Driver
Debug Port
Total weight
per unit: 5.2 g

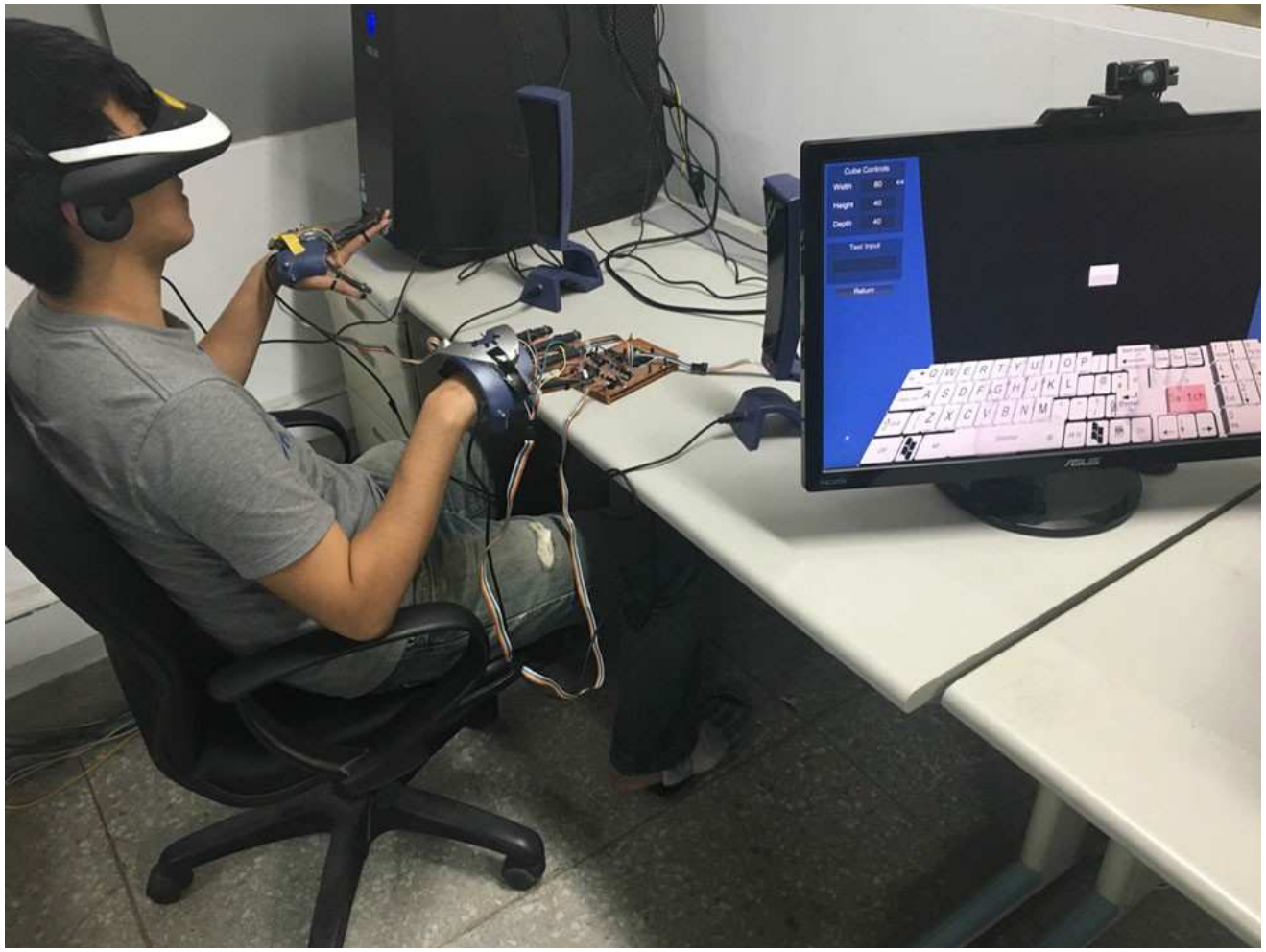

B
Double sided adhesive
2 mm N52
Magnets

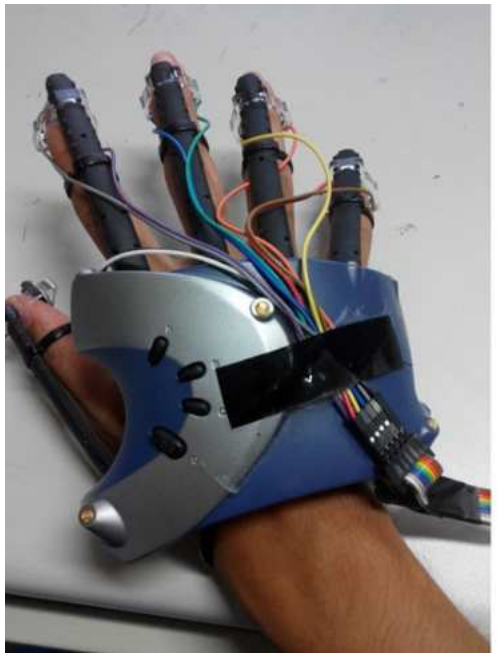

C

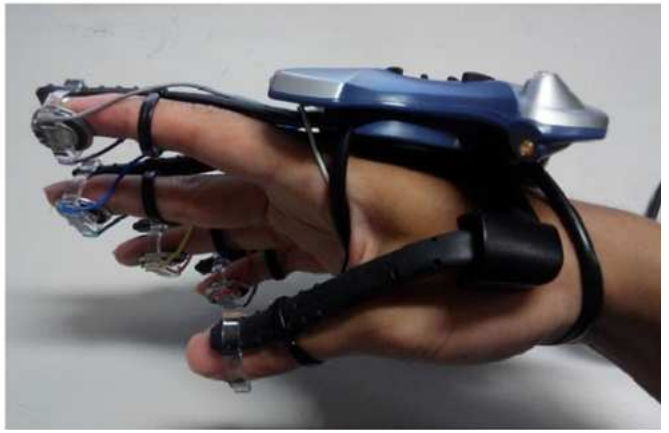

D
Haptics



# Tactile feedback







# XR development platforms

- Unity Engine
- Unreal Engine
- Vuforia Studio



# Unity 3D

- The most accessible game engine
- Abundant online learning resources
- Support 2D/3D application development
- Using C#

# Unreal

- Powerful rendering
- Few computing resource requirement
- Great software liability
- Using C++

# XR Hardware

What kind of devices ...??

- Mobile Device
- Tablets
- Laptops
- Head Mounted Display (HMD)

# Mobile Devices

# AR Head Mounted Display

HoloLens2

Epson


Google Glass

# VR Head Mounted Display

Oculus Quest

HTC Vive


Valve Index

# AR Hardware

- Advantage
  1. Immersive
  2. Connect to real world
  3. Hand-free

- Disadvantage
  1. Small view sight
  2. Uncomfortable
  3. Low battery capacity
  4. Expensive

# Types of see through headsets

- **Video-see through** devices use cameras to capture the real-world environment and display virtual content on top of it. This allows the user to see both the virtual and real world simultaneously.
- **Optical-see through** devices use transparent displays to overlay virtual content directly onto the user's view of the real world.

# Tracking

- Tracking process in VR is the continuous detection of the position (coordinate values) and orientation of the objects within a physical space.
- By identifying exactly where the head mounter display (HMD), controllers, and other accessories are located and how each is oriented, a VR headset can translate your body's movements in the real world to corresponding movements in the virtual world.
- Tracking can be achieved internally (e.g., by the headset itself) or externally (e.g., by an object or set of objects separate from the VR headset).

# Tracking

- Head tracking
- Hand tracking
- Eye tracking
- Full body tracking
- Object tracking

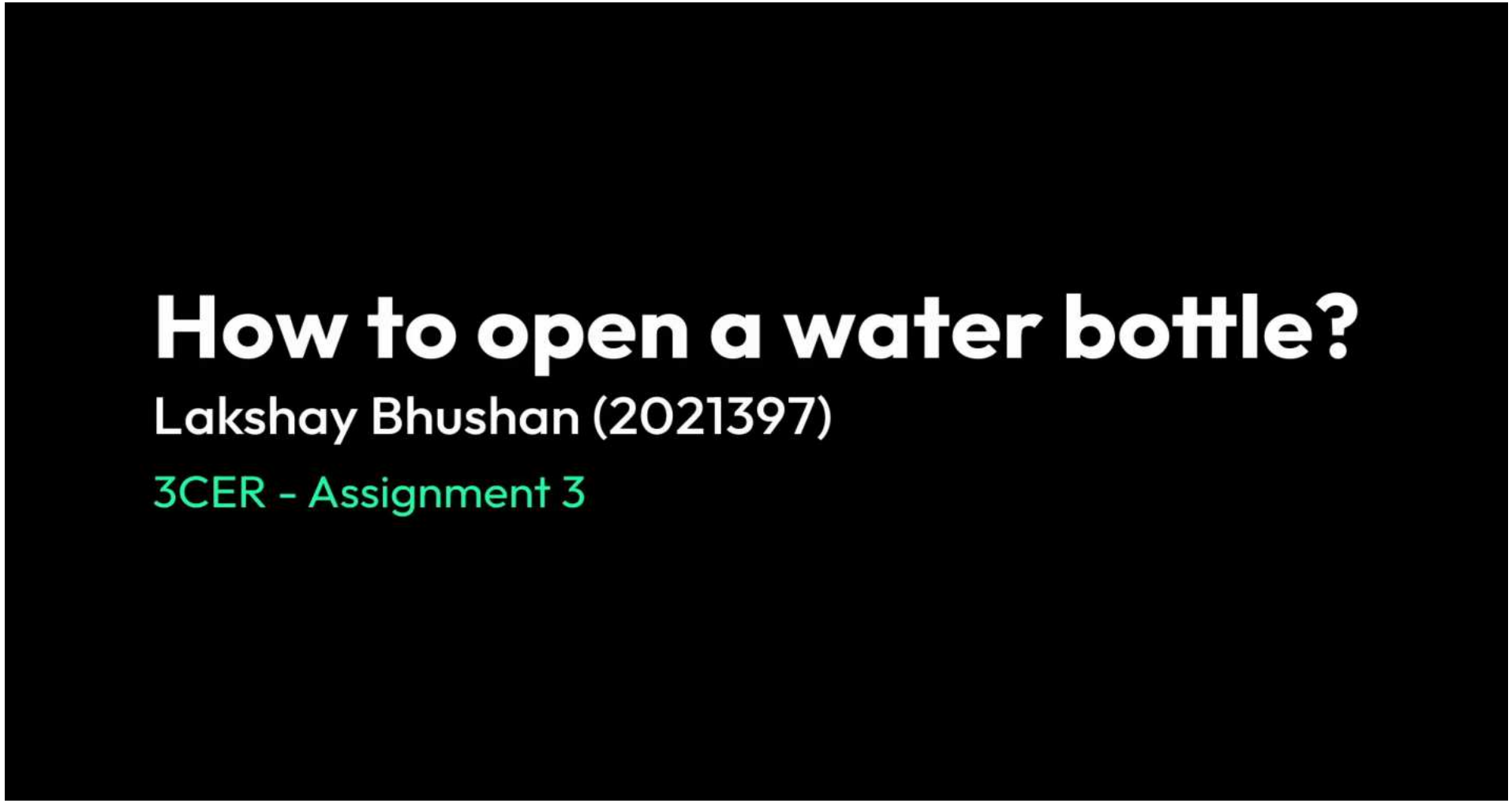
# Tracking


VIVE EDUCATION
VIVE Pro 2 x VIVE Tracker (3.0):
Go beyond controllers
VIVE
VIVE

# Tracking in AR

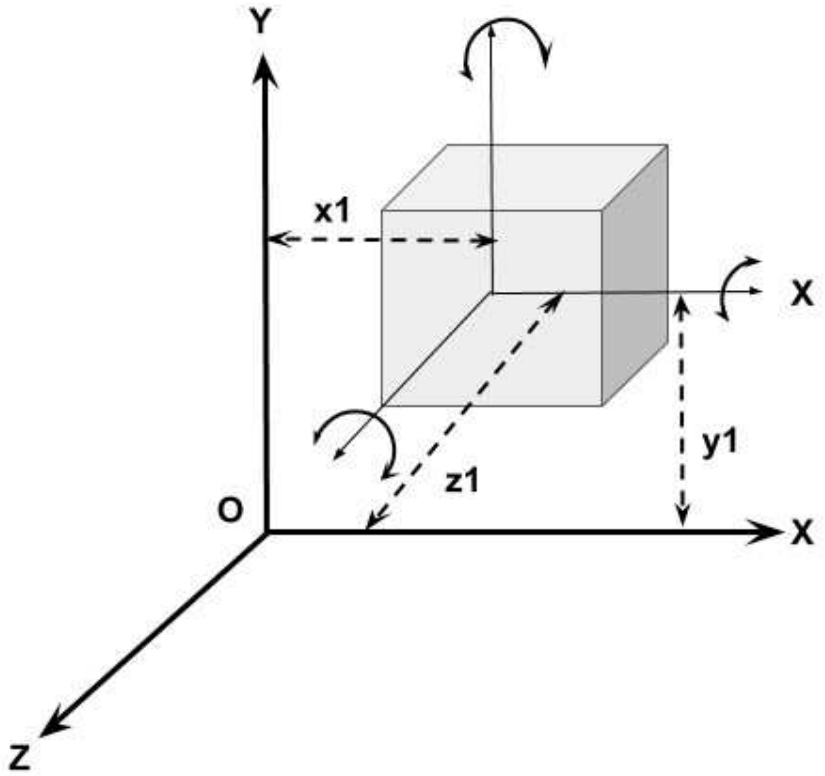
The AR system tracks the movement of objects and estimates their pose (position and orientation) in real time. This is achieved by continuously analyzing the sensor data and updating the virtual content's position and orientation relative to the tracked objects. Tracking ensures the correct placement of the virtual object in the real world.

# Tracking


How to open a water bottle?
Lakshay Bhushan (2021397)
3CER - Assignment 3

# Role of Degrees of Freedom (DoF) in Tracking

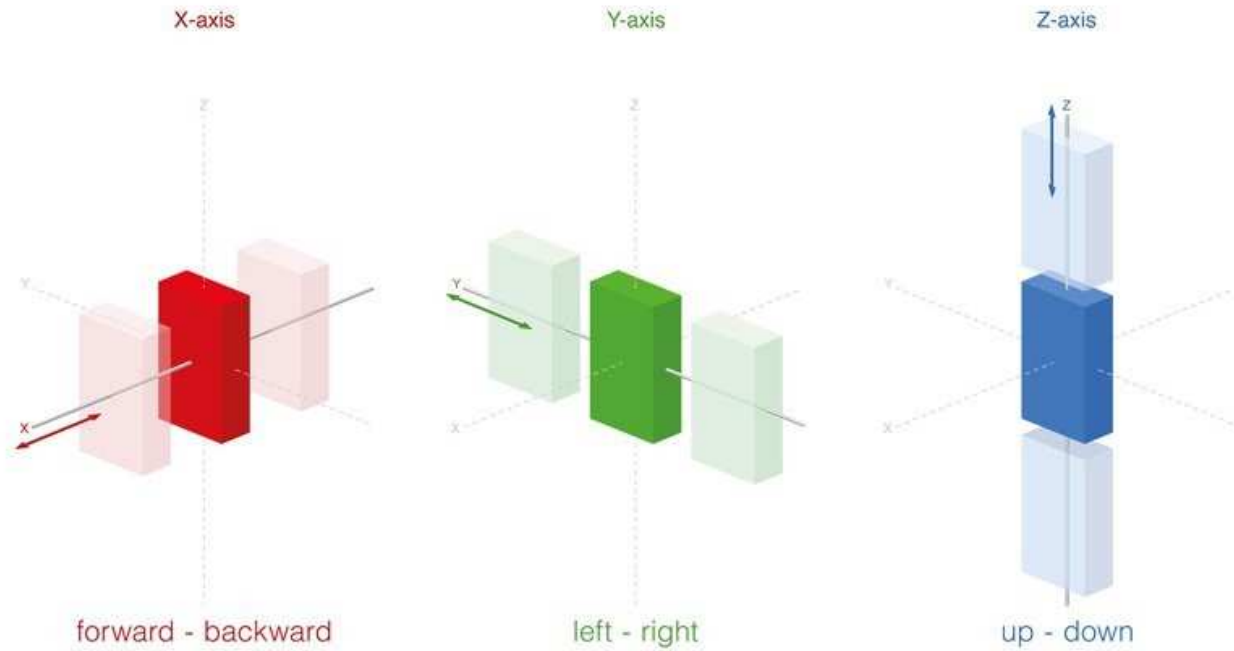
- Number of independent movement of an object is known as degrees of freedom.
- Degrees of freedom applies to two types of motion: Translational and rotational

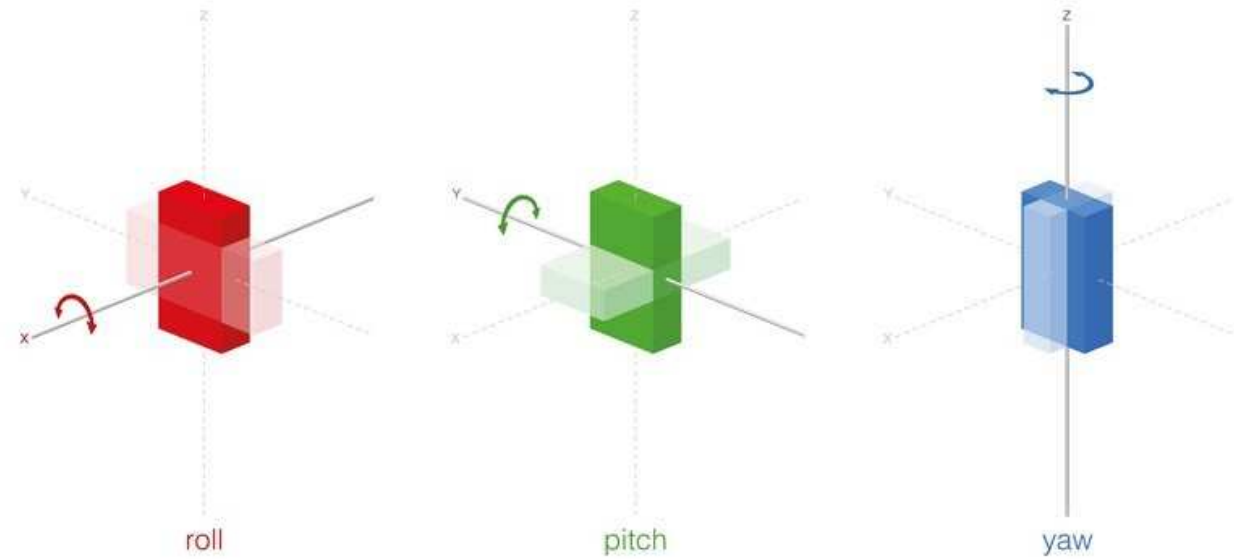


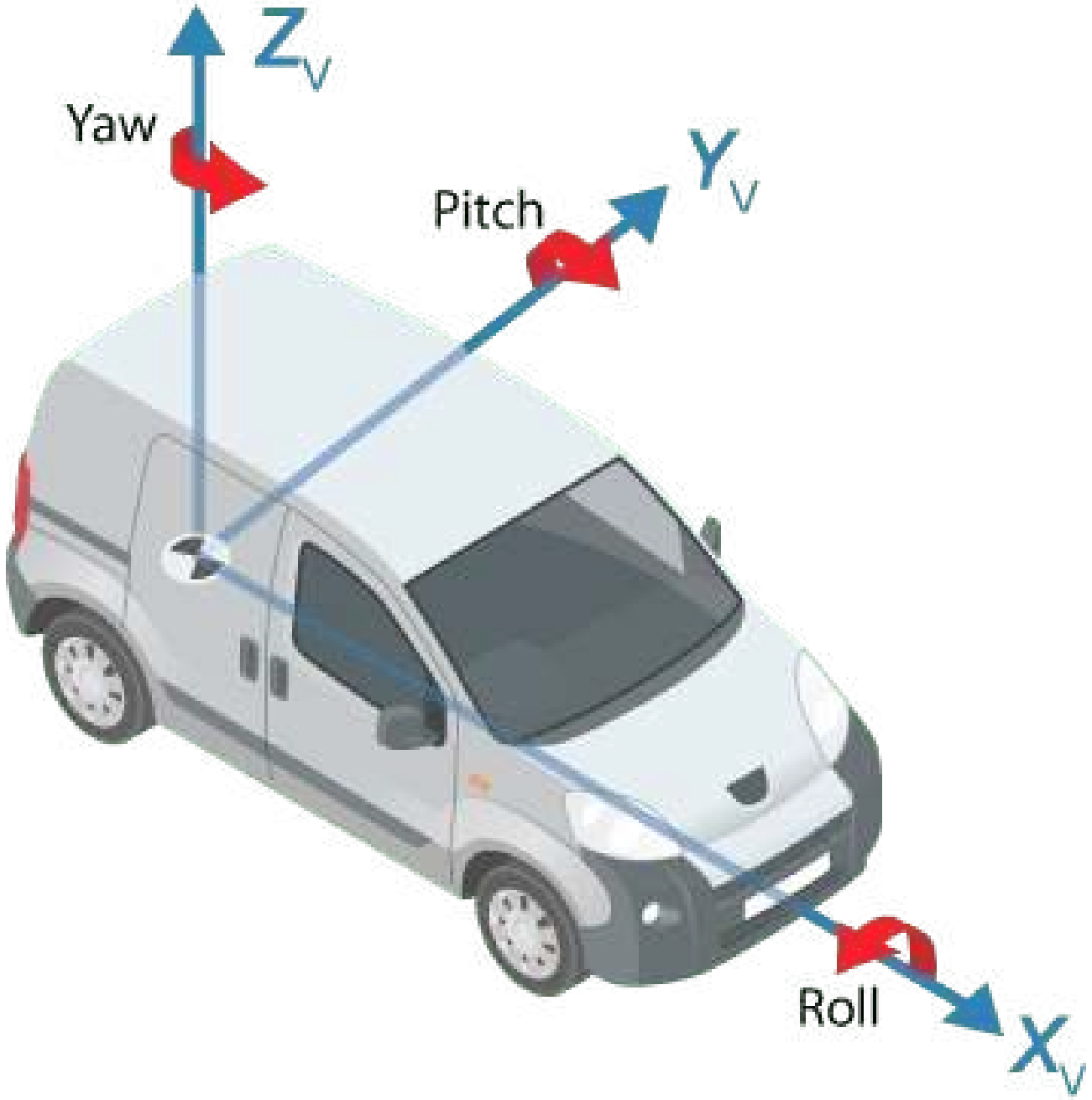
# 3 Degrees of Freedom (3DoF)

- In VR, 3DoF means that only three axes of movement can be tracked by the device — namely, the rotational axes of rolling, yawing, and pitching
- The 3DoF VR headset you wear will register all the different ways you may turn your head to allow you to look around the 360-degree environment freely. However, since translational movements are not tracked with 3DoF, the device will not recognize when you step left, right, forward, or backward

# Six degrees of freedom – 6DoF

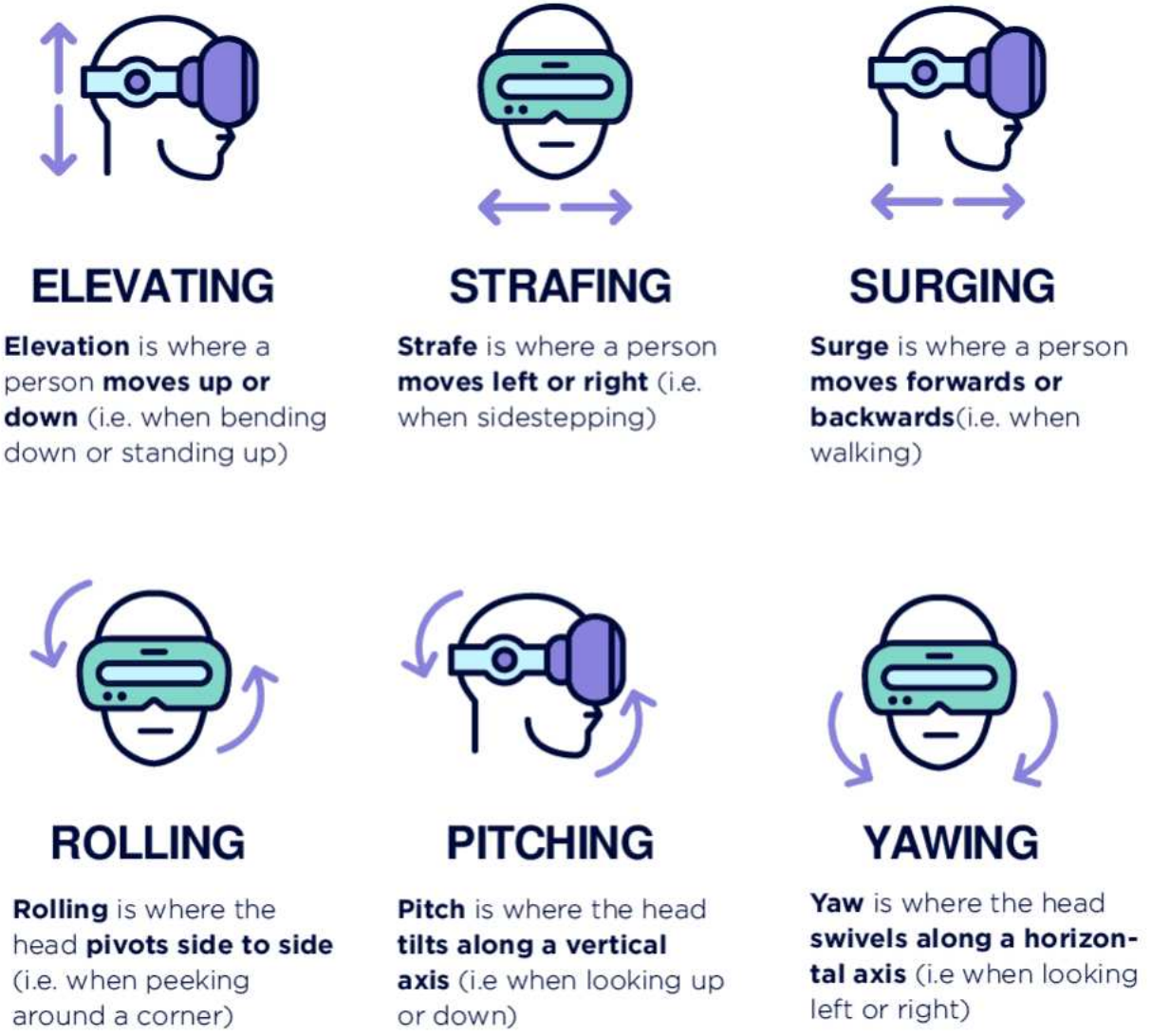



$Z_V$
Yaw
$Y_V$
Pitch
Roll
$X_V$

# 6 Degrees of Freedom (6DoF)

- A VR headset with 6 degrees of freedom (6DoF) can track all six axes of movement: rolling, yawing, pitching, strafing, elevating, and surging.



# Emerging Technologies

- Robotics
- Artificial intelligence
- Drones
- Internet of Things
- Large language model (LLM)
- Generative AI
- Haptics
- Brain computer interface
- Self-driving car