Course Code 005636 (Fall 2021)

# Multimedia


## Introduction to Augmented Reality (AR) and Virtual Reality (VR)

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# Introduction to AR/VR

## Contents

- AR: Applications and Technologies
- VR: Applications and Technologies

**Book: Virtual & Augmented Reality by Paul Mealy**

- Principles of Animation

# Introduction to AR/VR

## What is Augmented Reality (AR)

AR is a way of viewing the real world (either directly or via a device such as a camera creating a visual of the real world) and “augmenting” that real world visual with computer-generated input such as still graphics, audio, or videos.

Definition: the computer-generated content in AR is an overlay on top of the real-world content.


AR Pokémon Go being played on an Android

# Introduction to AR/VR

## What is Virtual Reality (AR)

VR is an immersive computer-simulated reality that creates a physical environment that does not exist.
Although the digital environments could be based on real places (such as the top of Mount Everest) or imagined ones (such as the underwater city of Atlantis), they exist apart from the current physical reality.

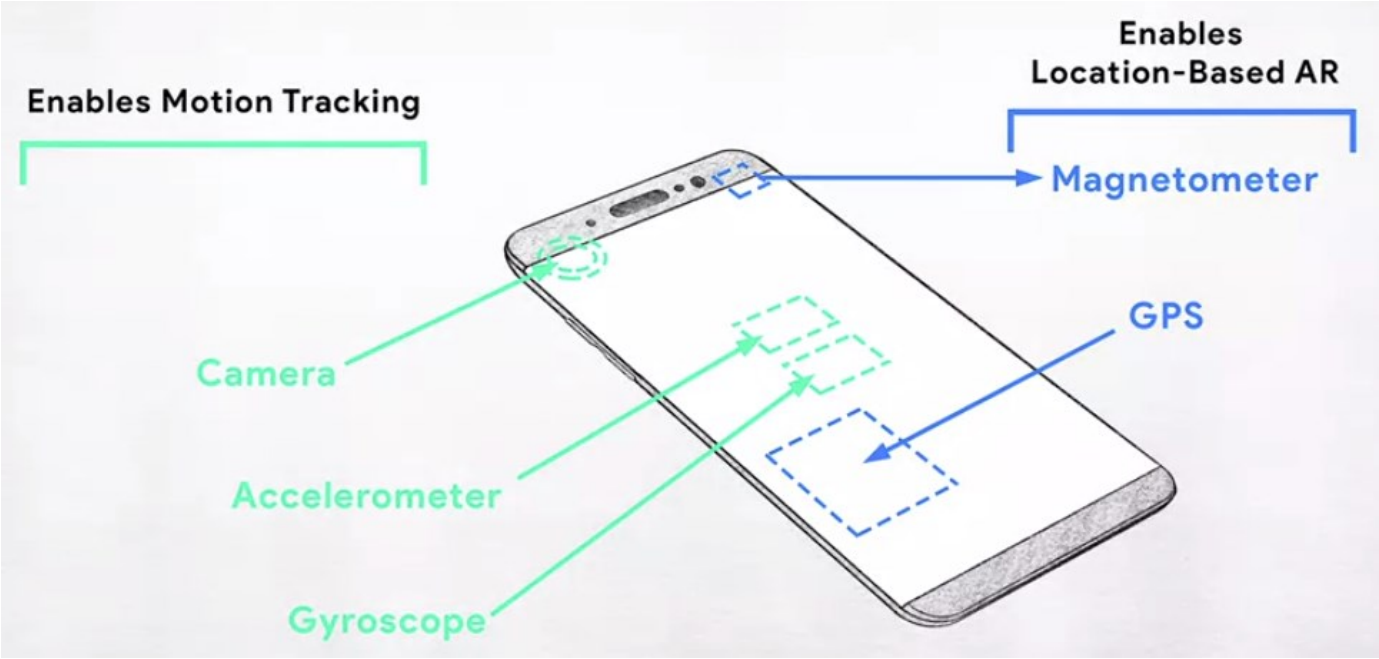
TheBlu

- ✓ A digital media franchise
- ✓ VR-based interactive simulations of underwater environments in the oceans.

Example of a VR environment. It's a screen shot of WEVR's VR experience, *TheBlu,* which allows users to explore undersea coral reefs and ocean depths, including an encounter with an 80-foot whale.

# Introduction to AR/VR

## How is AR/VR Possible

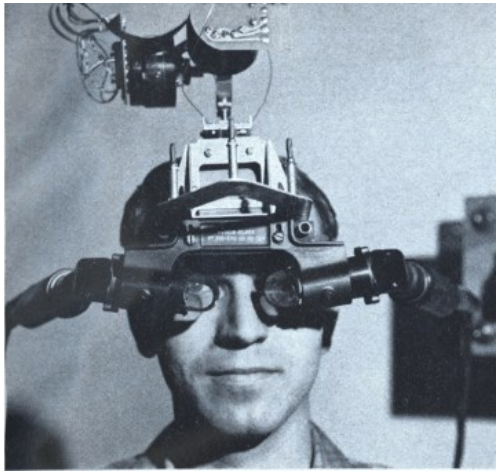



Many of the components in smartphones—gyroscopes, cameras, accelerometers, miniaturized high-resolution displays—are also necessary for AR and VR headsets.

The high demand for smartphones has driven the mass production of these components, resulting in greater hardware innovations and decreases in costs.

# Introduction to AR/VR

## History and Notes on AR/VR



- Humankind's first foray into immersive reality through a head-mounted display (HDM) was the "Sword of Damocles," created by Ivan Sutherland in 1968.

- The term "Augmented Reality" was coined by two Boeing researchers in 1992.

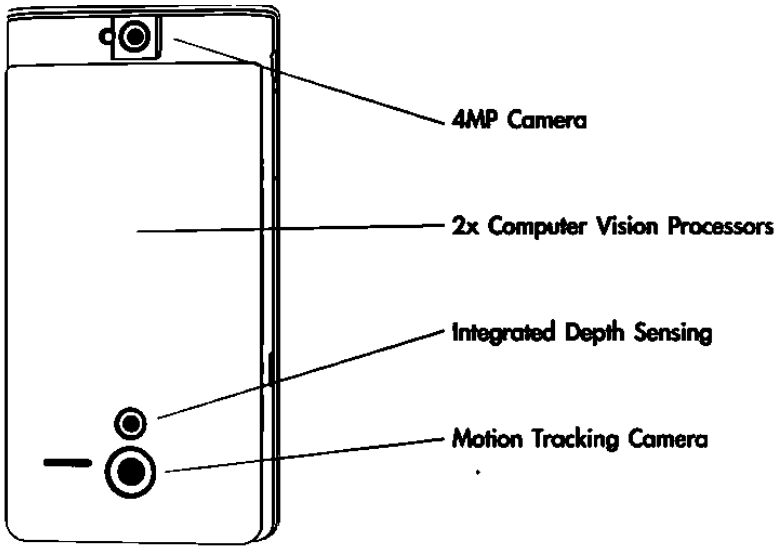
- A standalone headset is a VR or AR headset that does not require external processors, memory, or power.

- Through the combination of their hardware and software, many smartphones can view AR experiences that are less immersive than HMDs.

# Introduction to AR/VR

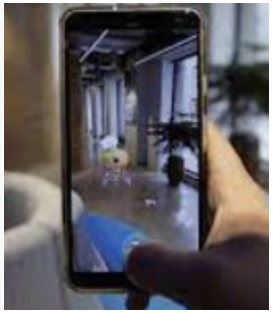
## AR Evolution in Google

Glass is a small, lightweight wearable computer with a transparent display for hands-free work.




Tango (aka Project Tango) was an AR computing platform.

ARCore



ARCore: SDK developed by Google that allows for AR applications to be built.

# Introduction to AR/VR

## Some Other Types of Virtual and Augmented Reality

**Mixed reality (MR):** It may take your view of the real world and integrate computer-generated content that can interact with that view of the real world. In this way, MR can sometimes function similarly to VR and sometimes function similarly to AR

AR-based MR: The digital content can act as if it were a part of the real world. Example: Bounce a digital soccer ball off the real-world walls and floor.

Microsoft HoloLens: A headset that scans the physical environment to mix in digital objects. It projects the digital environment onto translucent visors and enables user's hands to interact with those digital objects as if they were physically there.

# Introduction to AR/VR

## Some Other Types of Virtual and Augmented Reality

**Augmented Virtuality (AV):** The inverse of typical AR.
AV refers to predominantly digital environments in which there is some integration of real-world objects.

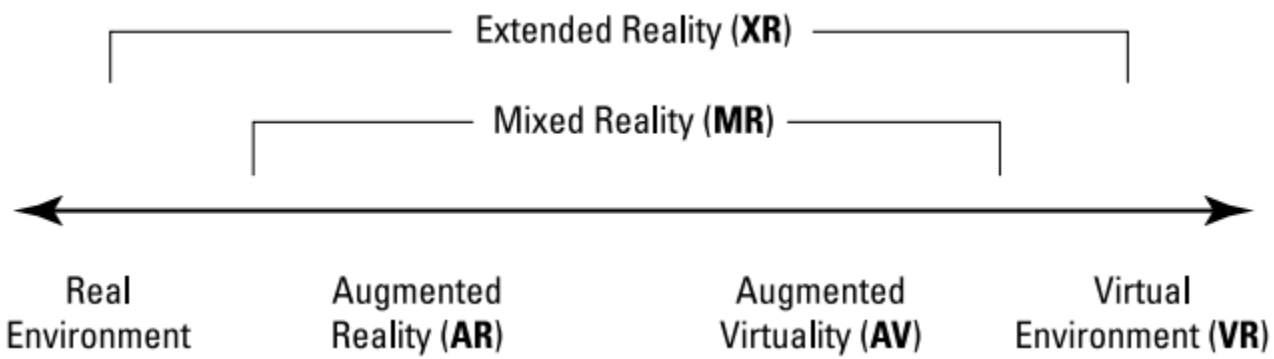
Some examples of AV include streaming video from the physical environment and placing that video within the virtual space or creating a 3D digital representation of an existing physical objects

**Extended reality (XR):** is the umbrella term for the entire spectrum of technologies discussed thus far (including VR, AR, and AV).

# Introduction to AR/VR

## Paul Milgram's reality–virtuality continuum

The virtuality continuum is a scale used to measure a technology's amount of realness or virtualness. On one end of the scale is the completely virtual, and on the other end is the completely real. XR spans the full spectrum of this scale, from end to end.



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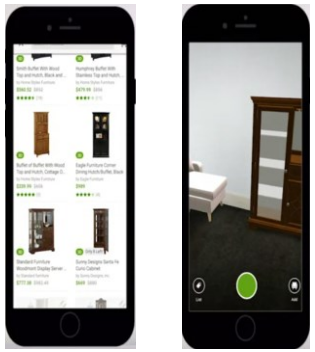
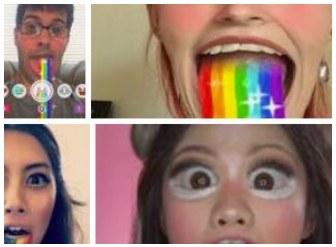
## AR Applications (1/2)



Shopping & Retail

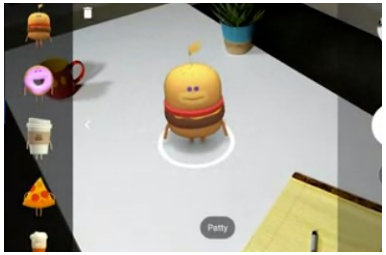
Warehouse Navigation & Architecture

Gamming



Snapchat Filter

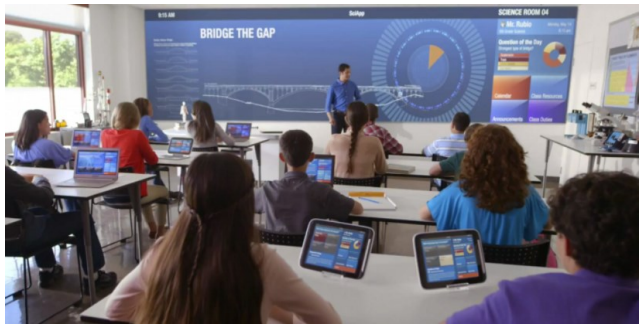
FB Spark AR



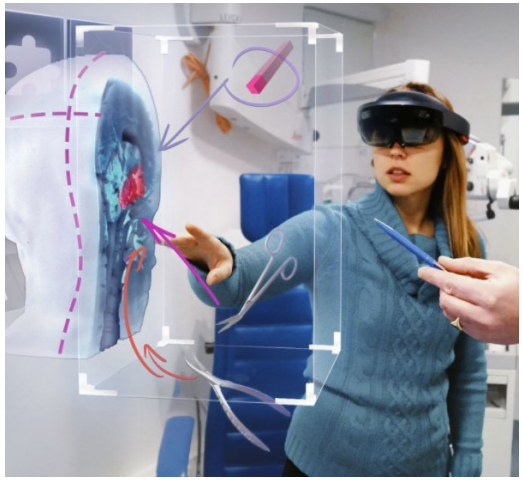
Google 3D Sticker

# Introduction to AR/VR

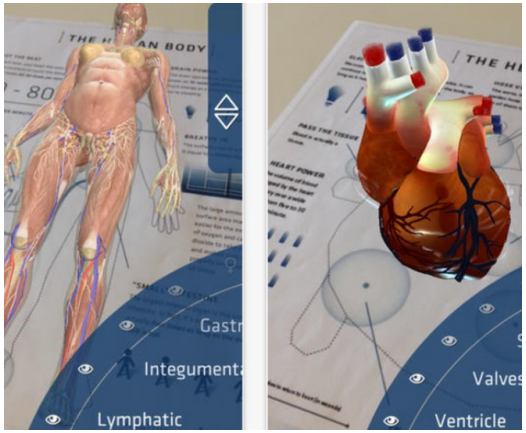
## AR Applications (2/2)




Classroom Education



Medical Education




Training

Real Time Assist During Surgery

# Introduction to AR/VR

## VR Applications

Mental Health

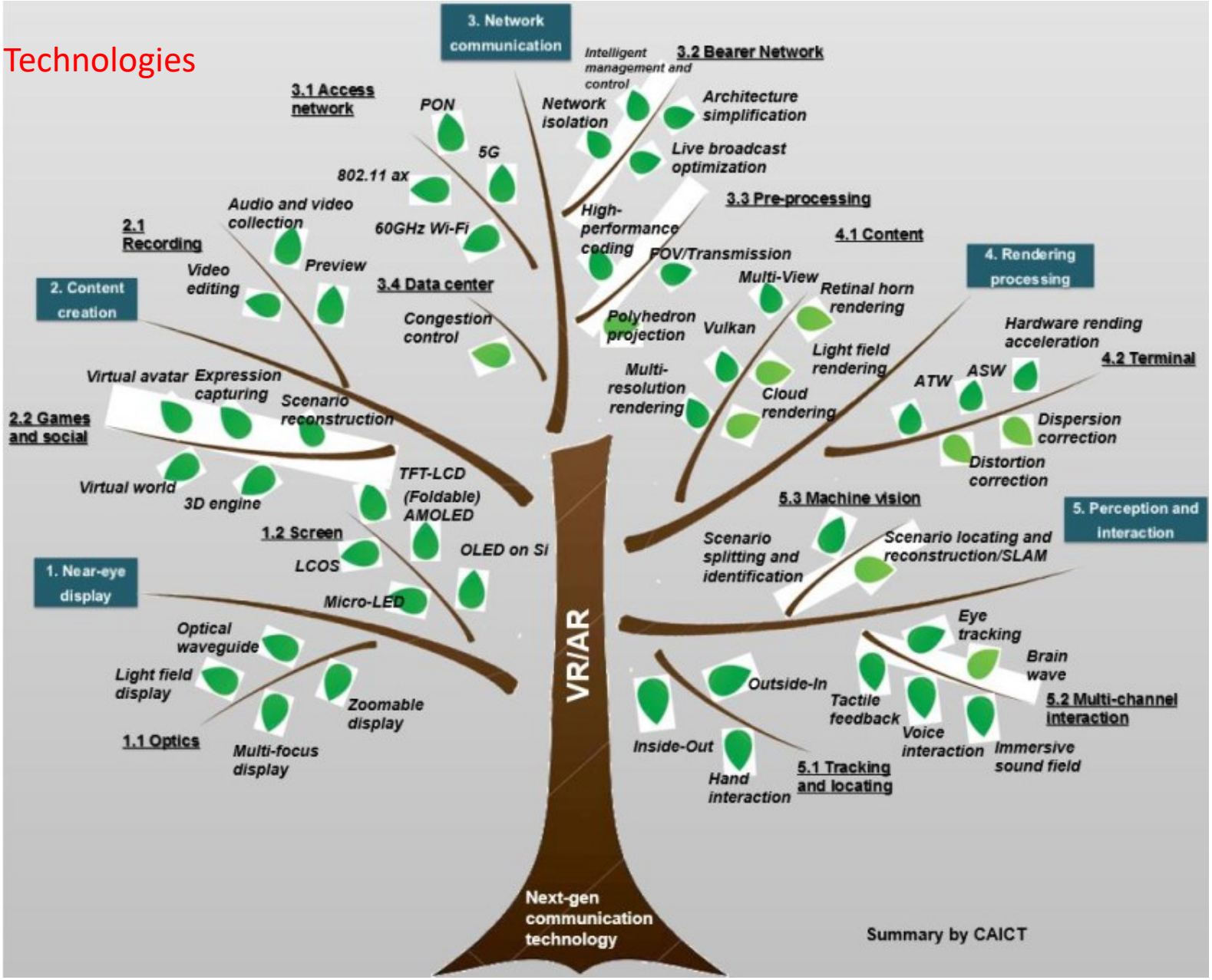
Medical Training

Military


Fashion Industry

# Introduction to AR/VR

AR/VR Technologies



# Introduction to AR/VR

## Virtual Reality: Recent Status

Most VR hardware: Generally a headset/integrated audio/motion controller combination.

| | HTC Vive | Oculus Rift | Windows Mixed Reality | PlayStation VR |
|---|---|---|---|---|
| Platform | Windows or Mac | Windows | Windows | PlayStation 4 (gaming console) |
| Experience | Stationary, room-scale | Stationary, room-scale | Stationary, room-scale | Stationary |
| Field of view | 110 degrees | 110 degrees | Varies (100 degrees) | 100 degrees |
| Resolution per eye | 1,080 x 1,200 OLED | 1,080 x 1,200 OLED | Varies (1,440 x 1,440 LCD) | 1,080 x 960 OLED |
| Headset weight | 1.2 pounds | 1.4 pounds | Varies (0.375 pound) | 1.3 pounds |
| Refresh rate | 90 Hz | 90 Hz | Varies (60–90 Hz) | 90–120 Hz |
| Controllers | Dual motion wand controllers | Dual motion controllers | Dual motion controllers, inside-out tracking | Dual PlayStation move controllers |

Virtual Reality Desktop Headset Comparison

# Introduction to AR/VR

## Virtual Reality: Recent Status

Each headset may support multiple mobile devices and, thus, not have a single specification it adheres to.

| | Samsung Gear VR | Google Daydream | Google Cardboard |
|---|---|---|---|
| Platform | Android | Android | Android, iOS |
| Experience | Stationary | Stationary | Stationary |
| Field of view | 101 degrees | 90 degrees | Varies (90 degrees) |
| Resolution | 1,440 x 1,280 Super AMOLED | Varies (Pixel XL 1,440 x 1,280 AMOLED) | Varies |
| Headset weight | 0.76 pound without phone | 0.49 pound without phone | Varies (0.2 pound without phone) |
| Refresh rate | 60 Hz | Varies (minimum 60 Hz) | Varies |
| Controllers | Headset touchpad, single motion controller | Single motion controller | Single headset button |

Virtual Reality Mobile Headset Comparison

# Introduction to AR/VR

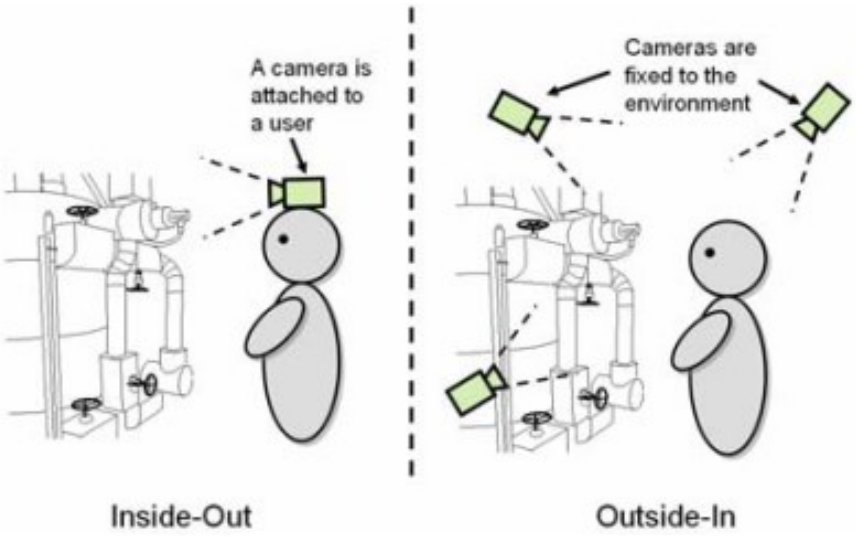
## VR Features

**Room-scale Experience:**
The ability of a user to freely walk around the play area of a VR experience, with his real-life movements tracked into the digital environment

**Stationary Experience:** The VR experience is designed around the user remaining seated or standing in a single location for the bulk of the experience

**Outside-in Tracking:**
Outside of the headset, additional hardware are placed around the room where the user will be moving around while in VR space.

**Inside-out tracking:**
It places the sensors within the headset itself, removing the need for external tracking sensors.



# Introduction to AR/VR

## VR Features

**Haptic feedback:**
The sense of touch designed to provide information to the end user.

**Example:** You're picking an item up. You're pressing a button. You've closed a door.

**HaptX VR gloves**

**3D Audio:** Human hearing itself is three-dimensional; we can distinguish the 3D direction that a sound is coming from, the general distance from the source, and so on

**Spatial Audio:** takes into consideration the fact that the user's ears are on opposite sides of the head and adjusts sounds appropriately

# Introduction to AR/VR

## VR Controllers


**Integrated Hardware Touchpad:**
Samsung's integrated touchpad (1) used for tapping, swipes, and clicks, as well as an integrated Home button (2) and Back button (3).

**Gaze controls:**
As eye tracking becomes more popular, gaze controls will likely see even more usage

**Standard Gamepads:**
Many headsets and controllers support standard gamepads or videogame controllers, a familiar input solution for many gamers.


**The Xbox One controller**

# Introduction to AR/VR

VR Controllers

**Motion Controller:**
It represents the position, orientation, and motion of user's hand.

**Hand Tracking:**
It enables headsets to track the user's hands in VR without any additional hardware worn on the extremities.

Hand tracking typically brings a representation of the user's actual hand (Digital Hand) into the virtual space.

# Introduction to AR/VR

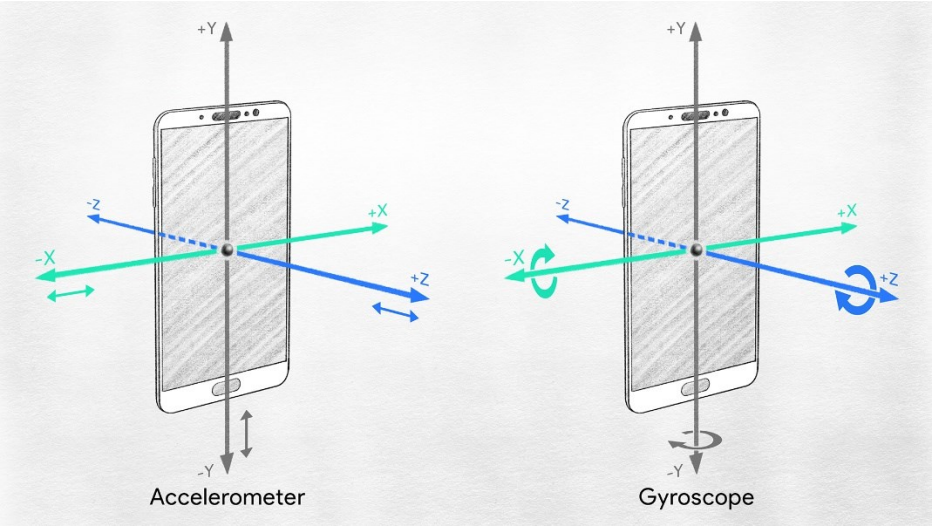
AR Functionalities: Hardware that makes Mobile AR work

See Slide 5 as well

**Motion tracking for AR**
Accelerometer: It measures change in velocity.

Gyroscope: It measures that rotation when the rotation of our phones change.

Phone Camera:  With mobile AR, the phone camera supplies a live feed of the surrounding real world upon which AR content is overlaid. The use of ML, DIP, and computer vision are common.




# Introduction to AR/VR

## AR Functionalities: Hardware that makes Mobile AR work

See Slide 5 as well

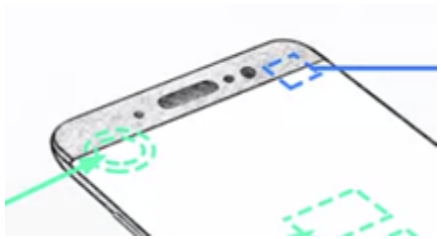
**Achieving Location-based AR**

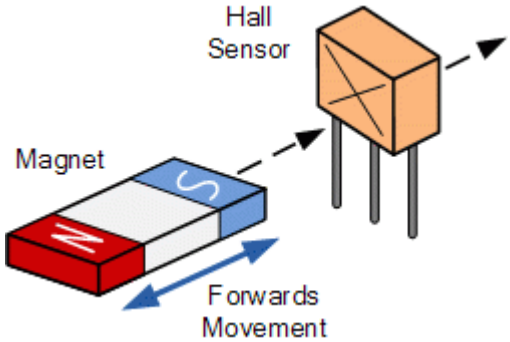
Magnetometer: Gives smartphones a simple orientation related to the Earth's magnetic field. That's how, our phone knows which direction is North. It thus allows to auto-rotate digital maps depending on our physical orientation.

GPS: A global navigation satellite system that provides geolocation and time information to a GPS receiver, like in smartphone.

**Achieving View of real world with AR**

Display: The display on our smartphone is important for crisp imagery and displaying 3D rendered assets.





# Introduction to AR/VR

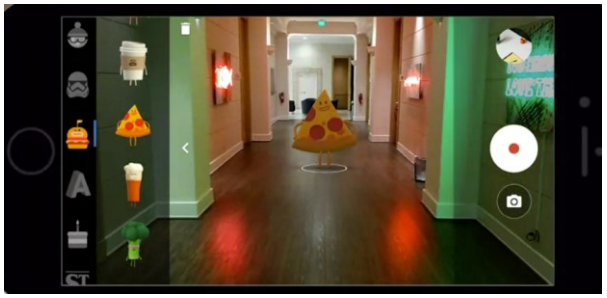
## AR Functionalities: Realism in AR

What makes AR feel real?

**Placing:** Stationary AR objects need to stick to one point in a given environment. This can be something concrete such as a wall, floor, or ceiling, or it could be suspended somewhere in mid air.

**Scaling:** When a car is coming toward you from a distance, it starts out small and gets bigger.

The mug on your coffee table doesn't jump around when you move your head.



Our physical distance from a given object and our orientation around it changes how they appear to us.

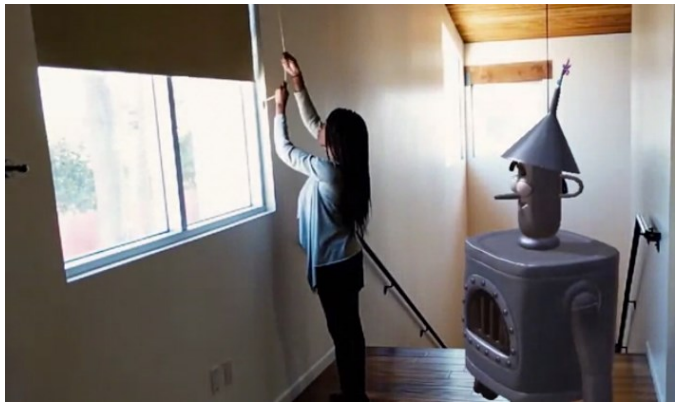
# Introduction to AR/VR

## AR Functionalities: Realism in AR

**Occlusion:** It refers to what happens when an image or object is blocked by another.

**Lighting:** The colors, shading, and shadows cast by these objects all need to behave properly both in the initial lighting of a scene and in the case of a lighting change.

Occlusion means hiding virtual objects behind other virtual objects, as well as in real world.



If the lights become dim during an AR experience, then the AR objects should change in color and shading appearance.

# Introduction to AR/VR

## AR Functionalities: Realism in AR

**Context-Awareness:** It refers to a capability to take into account the situation of entities.

AR needs to understand that there is a desk, a chair, and a table next to a bookcase, a vase, and a television. It needs to know which of these items is taller, shorter, fatter or wider than the others, and how this changes when the subject moves around in space.

# Introduction to AR/VR

## AR Functionalities: Building Blocks

**Motion Tracking Process**

Simultaneous localization and mapping (SLAM): Constructing or updating a map of an unknown environment while simultaneously keeping track of an agent's location within it.

SLAM processes require data collecting hardware like cameras, depth sensors, light sensors, gyroscopes, and accelerometers.

Ex. Google ARCore uses a process called Concurrent Odometry and Mapping or COM.

**Environmental Understanding**

The process begins with feature points. The same feature points used for motion tracking.

Google ARCore uses phone's camera to capture clusters of feature points along a surface. to create a plane.

# Introduction to AR/VR

## AR Functionalities: Building Blocks

**Light Estimation**

Phone's light sensor allow to automatically dims or brightens phone screen depending on place.

Scanning the camera images pixels to determine an average of incoming light. Which helps to decide how to best light an AR object inside of a specific environment.

# Introduction to AR/VR

## AR Functionalities: Challenges

**Interface issues and lack of UI metaphors**

<u>UI Metaphor</u>: These are common types of interfaces that apply to multiple sets of common technologies.

Example, our phone, our computer, maybe even refrigerator all come equipped with qwerty keyboards these days. As soon as we see one, we know what it is and how to use it.


Should we use our hands or our eyes to navigate menus

# Introduction to AR/VR

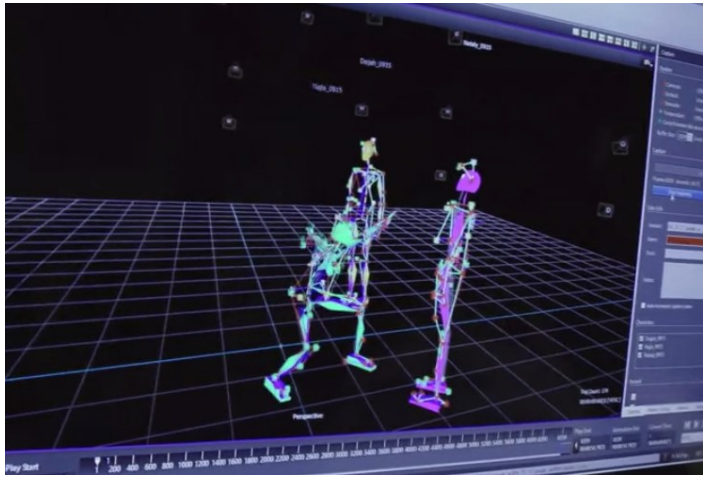
## AR Functionalities: Challenges

**Technical: Size, Power and Heat**

- ✓ Processors get heavy quickly when worn on our face. (Maybe, external computing pack)
- ✓ Rendering an AR experience takes a lot of power.
- ✓ The more power used, the more heat that gets generated, and the smaller the device, the slower it gets rid of that heat.

**3D Barrier:** In AR, things exist primarily in three dimensions.

Pretty much everybody knows how to take a photo but there was a time when that skill resided only with professionals. The equivalent of this in AR is three dimensional design. It



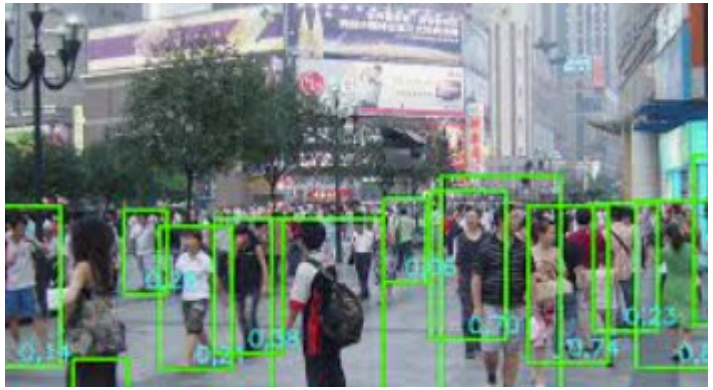
# Introduction to AR/VR

## AR Functionalities: Challenges

**Computer Vision**

- ✓ Computer Vision allow computers to see and understand the physical world.

- ✓ Unlike Google search, Computer Vision processes would actually allow search engines to see the pictures they are searching and recognize a dog on their own.



# Principles of Animation

## 12 Principles of Animation

Book: “The Illusion of Life” By Ollie Johnston and Frank Thomas
They introduced the 12 principles of animation:

1. Squash and Stretch
2. Anticipation
3. Staging
4. Straight Ahead Action and Pose-to-Pose
5. Follow Through and Overlapping Action
6. Slow In and Slow Out (aka, Ease In, Ease Out)
7. Arcs
8. Secondary Action
9. Timing
10. Exaggeration
11. Solid Drawing
12. Appeal

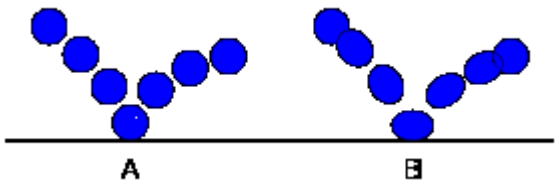
Highly Recommended YouTube Video: 12 Principles of Animation
https://youtu.be/uDqjIdI4bF4

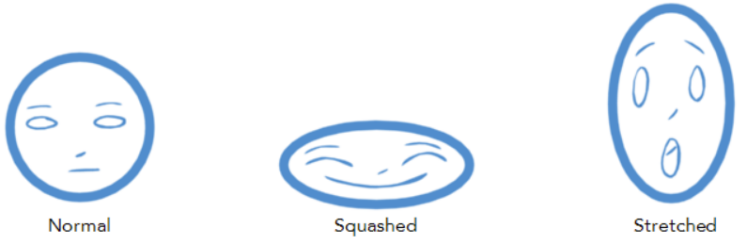
# Principles of Animation

## 12 Principles of Animation

**1. Squash and Stretch**

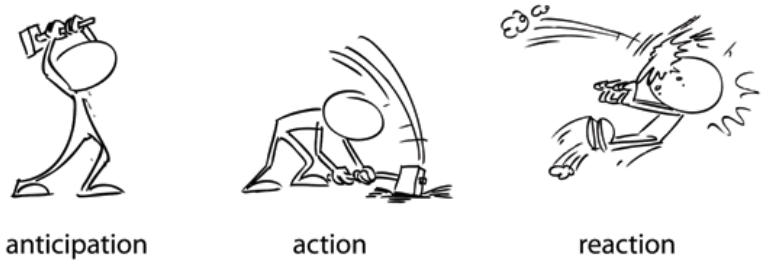
A bouncing rubber ball: The ball stretches when it travels up and down and squishes when it hits the ground.




**2. Anticipation**

Anticipation is the preparation for the main action. How ii might look if we were to jump in the air without bending our knees.



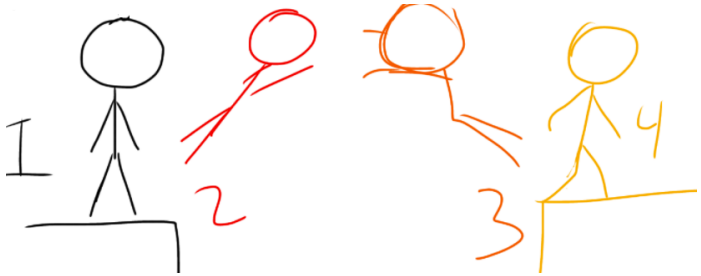
# Principles of Animation

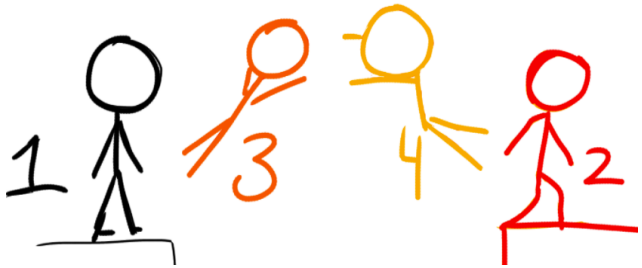
12 Principles of Animation

**3. Staging:**
How you direct the viewer's attention to the shot.


**4. Straight Ahead Action and Pose-to-Pose**
<u>Straight Ahead:</u> Draw the first drawing, and then draw the second, third, and so on, as the animation goes on.

<u>Pose-to-Pose:</u> Drawing a few key frames, and then fills in the intervals later.



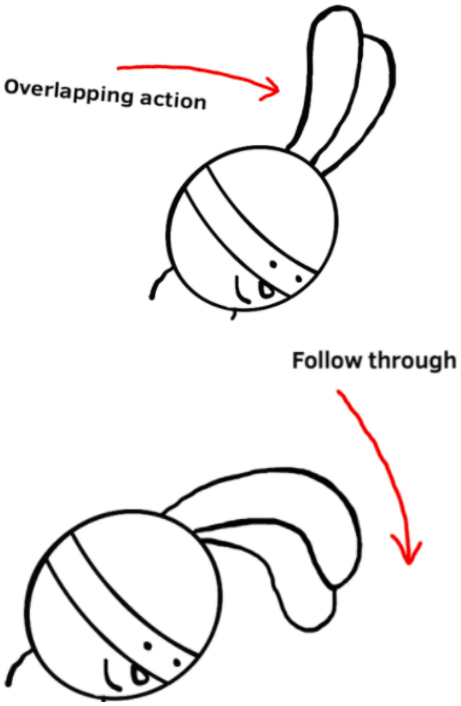
# Principles of Animation

## 12 Principles of Animation

**5. Follow Through and Overlapping Action**

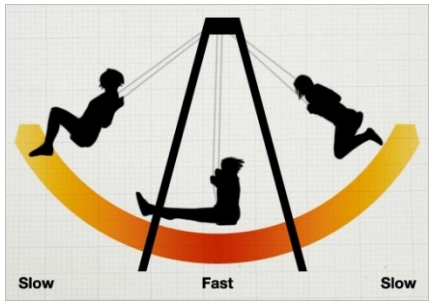
Overlapping: If a character is running across the scene, its arms and legs may be moving at a different rate from its head.

Follow through: The action that follows the main action
When a character stops running, its hair will likely continue to move for a few frames before coming to rest.




**6. Slow In and Slow Out (aka, Ease In, Ease Out)**

Most motion starts slowly, gets faster, and then slows down again before stopping.

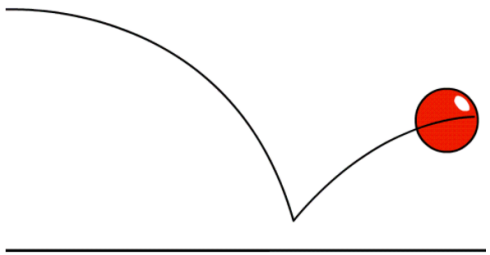


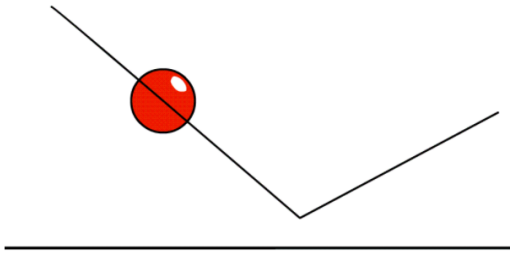
# Principles of Animation

## 12 Principles of Animation

**7. Arcs**

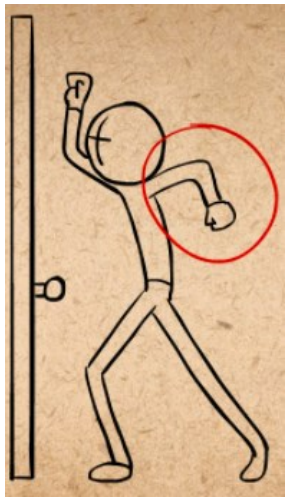
It's like a movement in a circular pattern, which is called an arc, most natural motion is in some form of an arc.

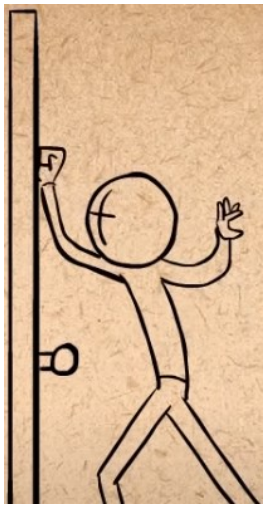




**8. Secondary Action**

Gestures that support the main action to add more dimension to the character's animation.





# Principles of Animation

## 12 Principles of Animation

**9. Timing:** Using the correct timing allows us to control the mood and the reaction of the characters and objects.

The personality and nature of an animation is greatly affected by the number of frames inserted between each main action.

Slow

Fast

**10. Exaggeration**

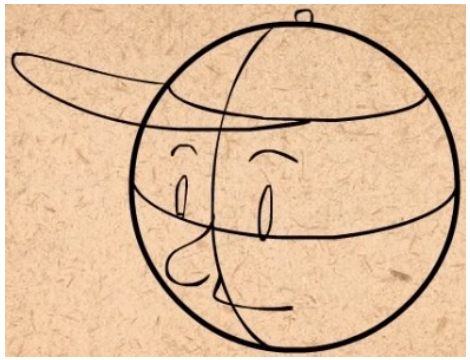
This principle is having every action, pose, expression taken to the next level, to increase the amount of impact on the viewer.

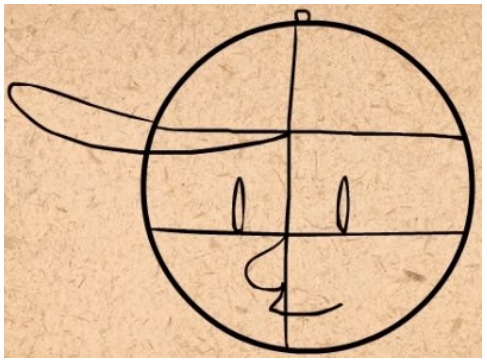
Exaggeration doesn't mean more distortion, but more convincing.

# Principles of Animation

## 12 Principles of Animation

**11. Solid Drawing**
Making sure that forms while they are 2D should be at least strive to look 3D with volume, weight, and balance.





**12. Appeal**

While not every character should be appealing, but they should at least be pleasing to look at.