UNIT - 1

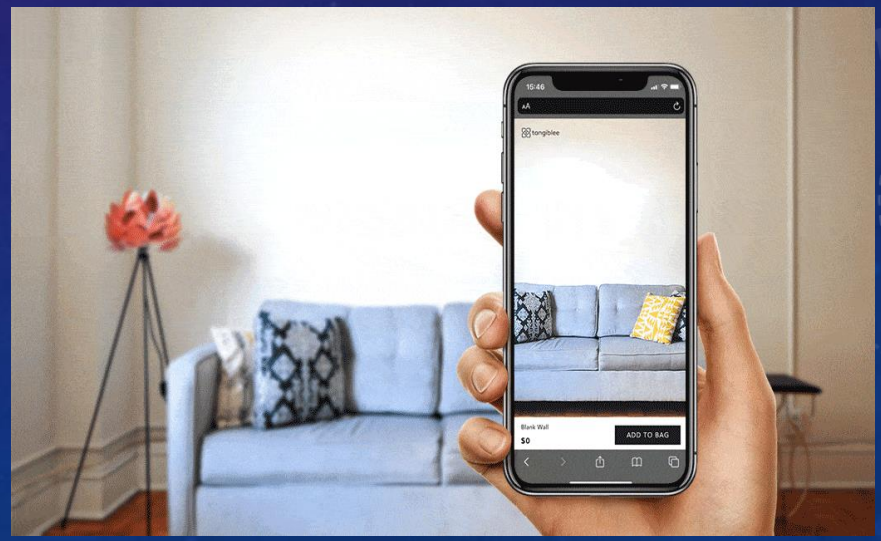
INTRODUCTION TO VIRTUAL REALITY

WHAT IS VIRTUAL REALITY??

- Virtual Reality means feeling the imaginary(Virtual) world, rather than the real one. The imaginary world is a simulation running in computer.
- Virtual Reality is the term used for computer generated 3D environments that allow the user to enter and interact with alternate realities.
- The definition of “Virtual” is near and “reality” is what we experience as human beings.

AUGMENTED REALITY

- Augmented Reality is different from the virtual reality.
- Augmented Reality = Real world + VR.

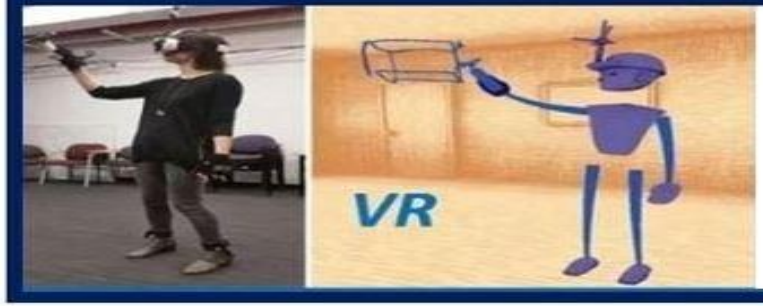


DIFFERENCE BETWEEN AR AND VR

Augmented Reality

Users can see virtual objects in their natural surroundings. For example, it can give them information about things in front of them.

Virtual Reality



An artificial environment where we can do things and interact with that environment using mobile devices such as VR goggles.

EVOLUTION OF VIRTUAL REALITY

1956: A Cinematographer called Morton L. Heilig came up with what he called the Sensorama, which was patented later in the year 1962. This invention was capable of simulating a person's every sense and featured stereo speakers as well as stereophonic 3D display.

1987: Jaron Lanier launches the term 'VIRTUAL REALITY'.

1993: First ever VR headset was introduced by the gamming company SEGA.

2014: Google Cardboard is introduced and becomes a grand success in VR technology market.

TYPES OF VIRTUAL REALITY

Non-Immersive

Semi-Immersive

Fully-Immersive

NON-IMMERSIVE VR

- This type of virtual reality refers to a virtual experience through a computer where you can control some characters or activities within the software, but the environment is not directly interacting with you.
- This technology provides a computer-generated environment, but allows the user to stay aware of and keep control of their physical environment.
- Non-immersive virtual reality systems rely on a computer or video game console, display, and input devices like keyboards, mice, and controller.
- A **video game** is a great **example of a non-immersive VR** experience.

SEMI-IMMERSIVE VR

- A semi-immersive virtual reality is a mixture of non-immersive and fully immersive virtual reality.
- This can be in the form of a 3D space or virtual environment where you can move about on your own, either through a computer screen or a VR box/headset.

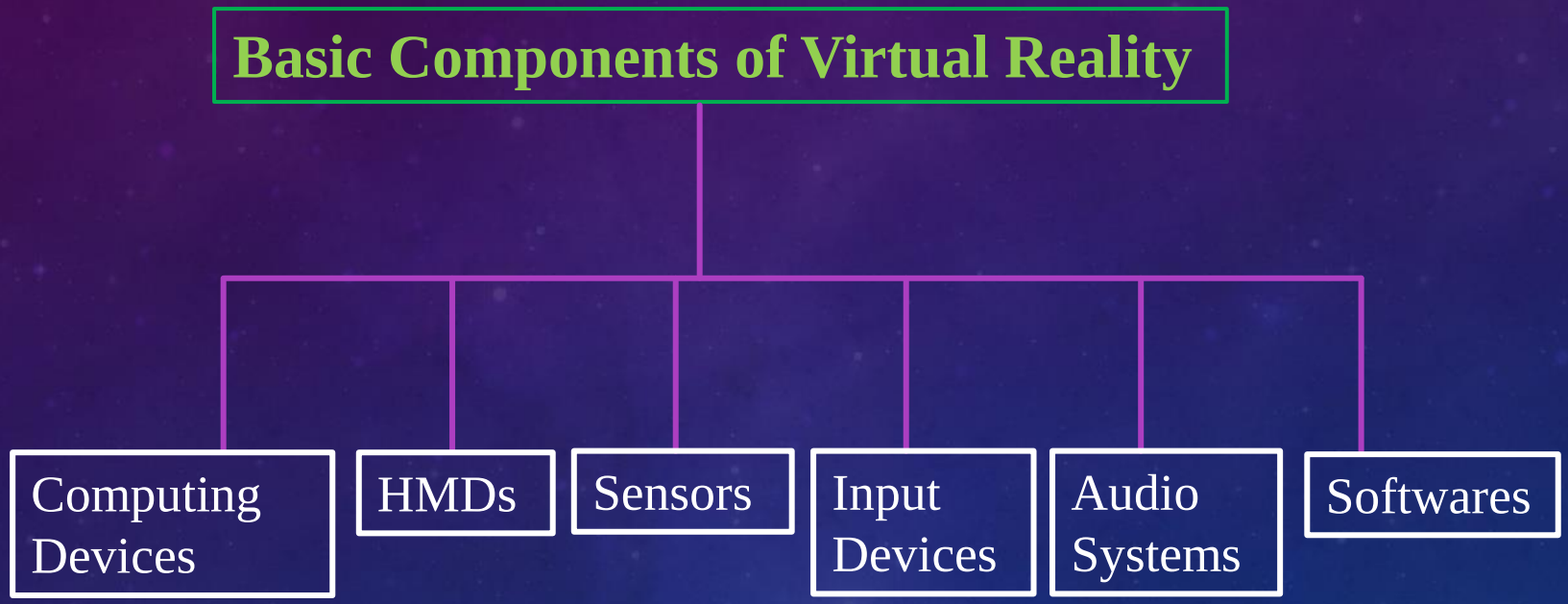
Example:- On a computer, you can use the mouse to move about the virtual space, and on mobile devices, you can touch and swipe to move about the place.

FULLY-IMMERSIVE VR

- Fully-immersive simulations give users the most realistic simulation experience, complete with sight and sound.
- To experience and interact with fully-immersive virtual reality, the user needs the proper VR glasses or a head mount display (HMD).
- VR headsets provide high-resolution content with a wide field of view.
- The display typically splits between the user’s eyes, creating a stereoscopic 3D effect, and combines with input tracking to establish an immersive, believable experience.

Example:- Gaming, Education, etc…

BASIC COMPONENTS OF VR



CONTD..

1) Computing device:

- It is a strong, powerful machine that processes and creates the 3-dimensional world.
- All other input devices pass their data onto it, it tracks the user movement and renders all the graphics.
- Computing devices should have a large amount of RAM, a good GPU, a powerful CPU, and a sufficient storage device.

CONTD..

2) HMDs:

- It is a **head-mounted display** that consists of two screens that display the virtual world in front of the users.
- They have motion sensors that detect the orientation and position of your head and adjust the picture accordingly.
- It also usually has built-in headphones or external audio connectors to output sound.
- Moreover, they have a blackout blindfold to ensure the users are fully disconnected from the outside world.

CONTD..

3) Sensors:

- Sensors are mostly incorporated into the headset of VR.
- They track users' poses and their head position, detect movement and rotation, and then pass all this data to the VR processor/computing device.
- Because of these sensors, the user can interact with the virtual environment.
- VR depends upon several sensors, including accelerometers, gyroscopes, magnetometers.

CONTD..

4) Input devices:

- Input devices are used by users in the VR system to interact with the virtual world in front of them.
- These devices might be a tool or a weapon in their artificial world.
- The input devices include mice, controllers, joysticks, gloves with sensors, and body tracking systems.

CONTD..

5) Audio system:

- Audio systems have a particularly important job in VR, ensuring a great VR experience in which users' brain is forced to think like they are in that artificial world.
- They are mostly integrated inside the HMD.
- VR provides spatial audio, so the users feel how real the virtual world is.

CONTD..

6) Software:

- Software is a crucial part of VR systems.
- The software is an application designed that runs on VR hardware and creates an artificial world.
- There are several different types of software based on what users need.

For example: games, simulations, medical ecosystems, etc.

PRIMARY FEATURES OF VR

- Virtual reality (VR) has four primary elements:

1) Virtual world:- The user feels like they are in the virtual world through what they see and hear.
2) Immersion:- As the user moves their head around, what they see changes as well, just as it would in real life.
3) Sensory feedback:- The user can experience touch, sound, and other sensations that mimic real-world experiences.
4) Interactivity:- It is the relationship between the user and the digital model. It describes the extent to which users can change the form and content of an environment.

PRESENT DEVELOPMENT ON VR

1) Education and Training
2) Entertainment and Gaming
3) Business and Industry
4) Social Interaction and Collaborations
5) Healthcare and Therapy
6) Metaverse

CONTD..

1) Education and Training:

- In the world of education and training, the future of virtual reality has already arrived.
- Schools and universities worldwide are leveraging virtual reality trends to provide immersive learning experiences.
- From exploring the pyramids of Egypt in history class to observing the solar system in science, VR is transforming classrooms into dynamic learning environments.
- Additionally, industries such as healthcare are using VR for training.
- Surgeons can practice complex procedures in a risk-free, virtual environment, enhancing their skills and reducing the risk of medical errors.

https://www.ge.com/news/reports/virtual-reality-bites-6-ways-industry-is-harnessing-the-power-of-vr-and-ar

CONTD..

2) Entertainment and Gaming:

- In the entertainment sector, VR's influence has been transformative.
- From virtual concerts and art galleries to hyper-realistic video games
- It provides immersive experiences that transport users to different worlds, making them active participants rather than passive viewers.
- As one of the most significant VR trends, the entertainment and gaming industry continues to innovate, promising even more captivating experiences in the future.
- Roblox is facilitating user-generated video games, and some companies are offering up little more than broken game worlds that happen to have NFTs attached.

CONTD..

3) Business and Industry:

- The future of VR in these industries will likely involve more immersive training programs, virtual tours, product demonstrations, and therapeutic treatments, among other applications.
- The social aspects of VR platforms are likely to become more prominent in the future.
- Architects, leveraging VR trends, are now crafting intricate 3D blueprints of their projects, breathing life into structures before the first brick is laid.
- Simultaneously, automotive engineers employ VR to conduct meticulous virtual crash analyses, contributing to safer, more robust vehicles.

CONTD..

4) Social Interaction and Collaborations:

- The use of VR for social interaction and collaboration is one of the most exciting trends in virtual reality.
- Social virtual reality platforms provide users with digital avatars and the ability to interact in real time within a virtual environment.
- These platforms are not just about socializing; they also offer opportunities for collaborative work, networking, and community building.
- From attending a virtual conference to hosting a virtual party, social VR platforms are providing new ways for people to connect and collaborate.

CONTD..

5) Healthcare and Therapy:

- The integration of VR into healthcare is another notable application in 2024.
- Beyond training, VR is being used for patient treatment and therapy.
- For example, it's being used to help treat phobias and post-traumatic stress disorder (PTSD) by gradually exposing patients to their fears in a controlled environment.
- In physical therapy, VR games are helping patients regain mobility and improve coordination in a fun and engaging way.

CONTD..

6) Metaverse:

- The metaverse is a virtual reality space where users can interact with other users and a computer-generated environment in real time.
- It's a network of shared, immersive virtual worlds that can be used for work, shopping, creating and playing games, and connecting with friends.
- **The metaverse is built on a foundation of blockchain technology** and provides digital experiences that are either a replica of or an alternative to the real world.
- It includes key aspects of civilization, such as: Social interactions, Currency, Trade, Economy, Property ownership.

BASIC CODE OF VR

```
<html>
 <head>
  <script src="https://aframe.io/releases/1.5.0/aframe.min.js"></script>
 </head>
 <body>
  <a-scene>
   <a-box position="-1 0.5 -3" rotation="0 45 0" color="#4CC3D9"></a-box>
   <a-sphere position="0 1.25 -5" radius="1.25" color="#EF2D5E"></a-
sphere>
   <a-cylinder position="1 0.75 -3" radius="0.5" height="1.5"
color="#FFC65D"></a-cylinder>
```

BASIC CODE OF VR

```
 <a-plane position="0 0 -4" rotation="-90 0 0" width="4" height="4"
color="#7BC8A4"></a-plane>
      <a-sky color="#ECECEC"></a-sky>
    </a-scene>
  </body>
</html>
```

WHAT IS MULTIMODAL INPUT AND OUTPUT INTERFACE IN VIRTUAL REALITY?

- A **multimodal input and output interface** in virtual reality refers to a system that allows users to interact with a virtual environment using multiple modes of input and output.
- This can include a combination of visual, auditory, haptic, and other sensory inputs, as well as outputs such as sound, vibration, and visual feedback.

INPUT DEVICES

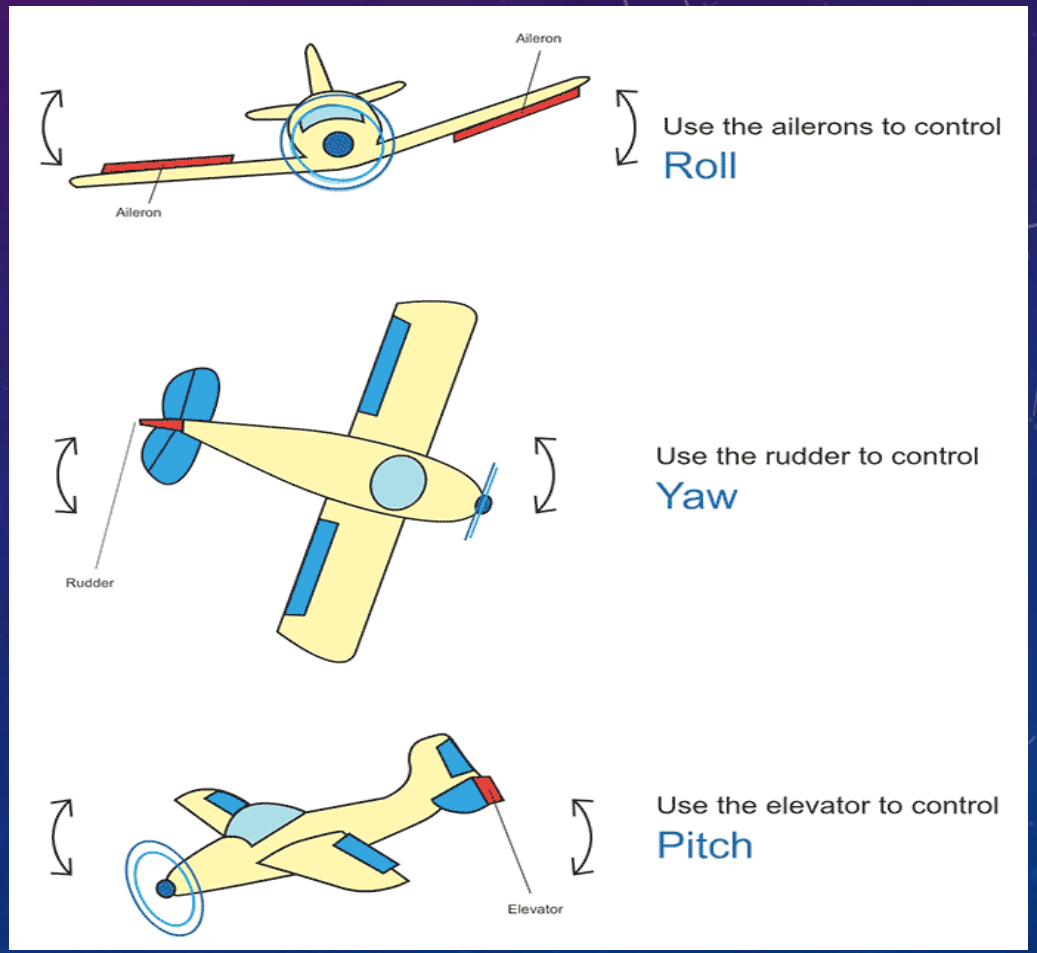
- Tracker
- Sensor
- Digital Glove
- Movement Capture
- Video-based Input
- 3D Manus
- 3D Sensor

OUTPUT DEVICES

- Visual Devices
- Auditory Devices
- Haptic Devices

TRACKERS

- The least information that Virtual Reality System requires, is the position and orientation of the viewer's head, needed for the proper rendering of images. Not only this, user can track other parts of human body like hand, legs or chest etc.
- "Three-dimensional objects have 6 degrees of freedom (DOF): three DOF for position coordinates (x, y and z offsets) and three DOF for orientation (yaw, pitch and roll angles)."



CHARACTERISTICS OF TRACKING DEVICES

•**Range** – Working volume, within which the tracker can measure position and orientation with its specified accuracy and resolution, and the angular converges of the tracker.

•**Resolution** – Smallest change in position and orientation that a tracker can detect. Smallest possible values mean better performance.

•**Accuracy** – The measure of the error in the reported position and orientation. It is usually in absolute values i.e. in mm for position or in degrees for orientation. Smaller values often lead to better accuracy.

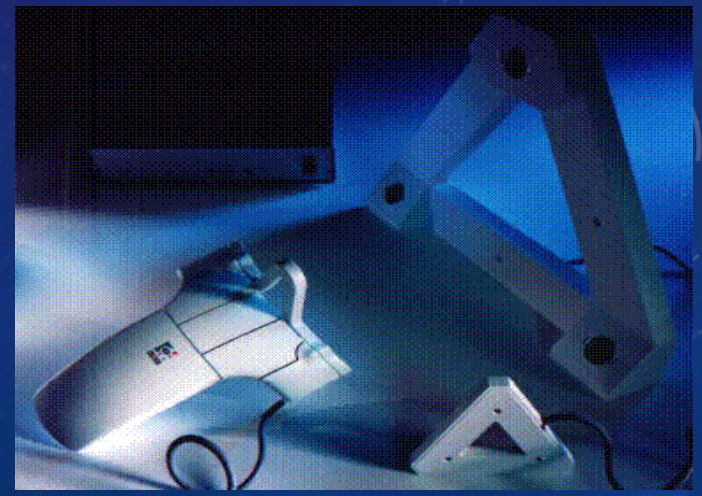
CONTD..

•**Latency** – The amount of time measured in ms between the user physical action and the beginning of the transmission of the report that represents this action. Lower values contribute to the high performance.

•**Update Rate** – Defines the number of measurements per second measured in Hz. Higher update rate supports the smoother tracking of the movements, but it requires more processing and more computational time.

ACOUSTIC TRACKERS

- Acoustic trackers are small sound-emitting devices that can detect and track organisms in aquatic ecosystems.
- It senses and produces ultrasonic sound waves to identify the orientation and position of a target. They calculate the time taken for the ultrasonic sound to travel to a sensor.
- The sensors are usually kept stable in the environment.
- Two trackers are in the following:
    - Mattel Power Glove
    - Logitech 6DOF Ultrasonic Head Tracker



MAGNETIC TRACKERS

- Immersive systems often use magnetic trackers.
- Typically, these trackers contain **static part**, a number of **movable parts** and **control unit**; static part recognizes as emitter or source while movable parts as receivers or sensors.
- The assemblies of emitter and receiver are quite similar because both have 3 mutually perpendicular antennae.
- Additionally, each antenna works on direct current or alternating current, generates magnetic fields (communication medium) according to the measurements.
- Receivers collect these generated magnetic field lines and feed the data to the control unit for the calculation of position and tracking.

CONTD..

- The most common magnetic trackers are in the following:
  - •Polhemus Fastrak - Used for Wrist Motion
  - •Ascension Flock of Birds - track the Motion of Multiple Sensors

OPTICAL TRACKERS

- Optical trackers use different configuration and methodologies. Explicitly, we can classify them into three main categories. But, with the increase in distance between tracked object and sensors, their accuracy reduces.
  - **Laser Ranging** – Onto an object, these systems transmit the laser light that passes through the diffraction grating. A sensor analyzes the diffraction pattern on the surface of that object to calculate its position and orientation.
  - **Pattern Recognition** – To determine the position and orientation, these trackers compare the known patterns with the sensed ones.

CONTD..

- **Beacon Tracking** – This methodology uses a set of beacons like LED and a number of cameras capturing the image of beacon’s pattern. By using the known geometries of beacons, we can derive the position and orientation of the tracked object.

MECHANICAL TRACKERS

- We use a mechanical linkage of rigid arms with joints between them to determine the position and orientation of a free point.
- In short, we determine the angles at the joints by using potentiometers and gears.
- Study of linkage construction combined with the angles' calculation helps us to find out the required entities.
- Fake Space Labs developed the following mechanical tracking device:
    - Binocular Omni Oriented Monitor

VIVE TRACKERS

- VIVE Trackers are a system that allows users to bring objects into a virtual environment.
- They can be used for virtual production, simulations, and motion capture.
- The Vive Tracker is a wireless, battery powered SteamVR tracked accessory that provides highly accurate, low latency 6 Degrees of Freedom (6DoF) motion tracking within a room scale environment.

EYE TRACKING DEVICES

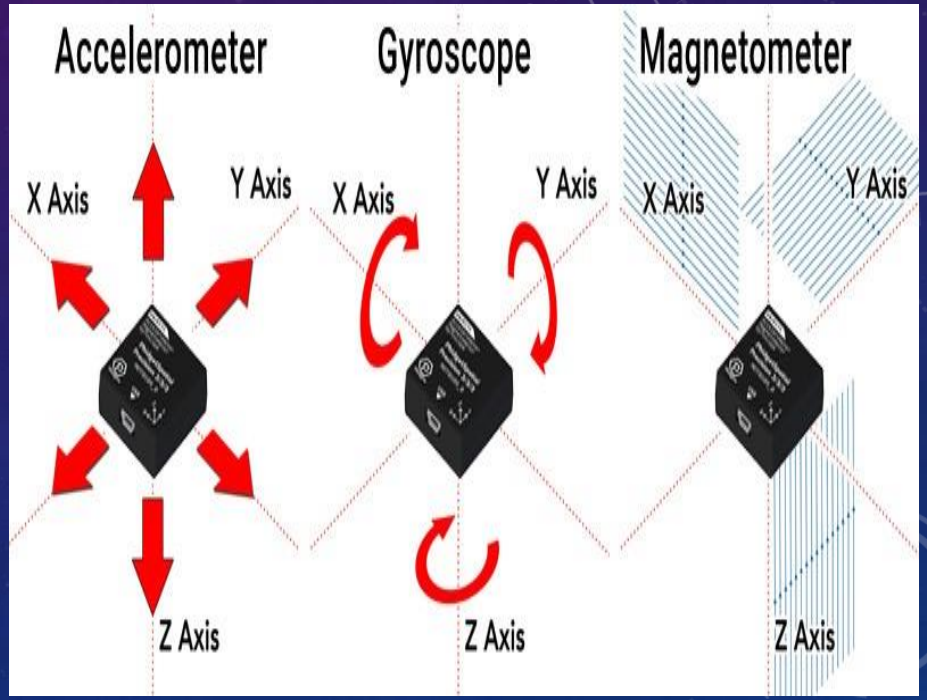
- The devices used for head tracking allow the proper rendering of images from user's field of view (FOV).
- It is important to note that visual **acuity** of the eye changes with the arc distance from the line of sight and clarifies that images don't need to have equal resolution and quality over the whole display area.
- Additionally, there are different technologies being used in eye trackers like image tracking, limbus tracking, electro-oculography (EOG) and corneal reflection. Look at the following tracker:
  - NAC Eye Mark Eye Tracker

SENSORS

- Sensors are a key technology in virtual reality (VR) systems. They track a user's location, position and orientation of their head and hands.
- VR devices use sensors to measure a user's motions and pass them to the VR processor.
- The most important sensor is the motion sensor, which uses accelerometers and gyroscopes to detect the movement and rotation of the user's head and hands.

CONTD…

- Accelerometers, magnetometers, and gyroscopes are all sensors that can measure motion:
  - •Accelerometers: Measure linear acceleration and the earth's gravitational pull.
  - •Magnetometers: Measure the earth's magnetic field to determine a compass heading.
  - •Gyroscopes: Measure angular velocity and changes in twist and angle.



CONTD…

Types Sensors in VR

- Accelerometer
- Gyroscope
- Magnetometer
- Motion sensor
- IMU sensor
- Ultrasonic sensor
- Infrared sensor

WORKING OF SENSORS

- Motion sensor detecting the movement and rotation of the user's head and hands in 3DoF (Degrees of Freedom) through accelerometers and gyroscopes.
- Ultrasonic sensor can be used in virtual reality (VR) to measure distance and navigate environments. They work by emitting high-frequency sound waves, typically between 20-40 kHz, and measuring the time it takes for the sound to bounce back. This allows the sensor to detect objects and determine distance.

WORKING OF SENSORS

- Infrared Sensor are used in VR technology to illuminate tracking sensors. This is especially important in low-light conditions, as tracking sensors may not be able to detect movements accurately.
- Image sensors are used in virtual reality (VR) and augmented reality (AR) to track the wearer's head and hands. These sensors are used to adjust the projected image on the viewscreen and place projected holograms.
- Proximity Sensor located between the lenses inside Oculus Go and Pico G2/4KS headsets. When the headset is in sleep mode and you put it on, this sensor automatically wakes the display, illuminating the lenses.

CONTD…

- **Variable reluctance sensor** is also known as a VR sensor, this sensor measures changes in magnetic reluctance(*measure the position and speed of ferrous object*).
- **Depth sensor used to** project a light pattern and capture reflected light data. They can identify surfaces, objects, and their distances.

WHAT ARE VR GLOVES???

- VR gloves are a type of wearable technology designed to immerse the user in a VR experience by making the experience more natural and realistic.
- The gloves are fitted with haptic technology that allows the user to interact with virtual objects in various ways.
- The virtual reality technology provides visual and graphical experiences at best.
- It is all about upended in the mid of a scene and sensing immersed because you are watching everything in panoramic panache.

CONTD…

- But …..
  - What if we talk about the touch sense?
  - What is the better experience than being able to feel the weight and the sense of the things in the virtual world you are witnessing?
  - When a user is feeling something, he is certainly out of the empire of the viewer and into the kingdom of a member of the action being performed.

Link:- https://filmora.wondershare.com/virtual-reality/top-vr-gloves.html

CONTD..

- They include:

•**Hand tracking feedback**: Allows users to see hand movements and gestures in virtual space.
•**Vibrotactile feedback**: Provides a range of sensations, from light touch to rough textures.
•**Force feedback**: Allows users to feel the size and density of virtual objects
•**Contact feedback**: Allows users to feel the shape of virtual objects and surfaces.
•**Temperature feedback**: Allows users to feel the temperature of virtual objects.

DIGITAL GLOVES

- Virtual reality (VR) gloves are wearable devices that allow users to interact with virtual environments using their hands.
- They are designed to make the VR experience more natural and realistic.
- VR gloves contain sensors and actuators to capture hand movements and provide haptic feedback. This allows users to interact with virtual objects in various ways.
- The gloves can also simulate complex sensations such as pressure, texture, and vibration.

CONTD…

GloveOne:

- This is a very sharp-looking couple of gloves, suitable just like the gloves people wear for BX or somewhat alike.
- The IMU, is immovable inside the logo that is present on the back of the user’s hand.
- The qualities of having IMU’s on the separate fingers, and this glove ensures precisely that.
- It also features actuators on every fingertip.

CONTD…

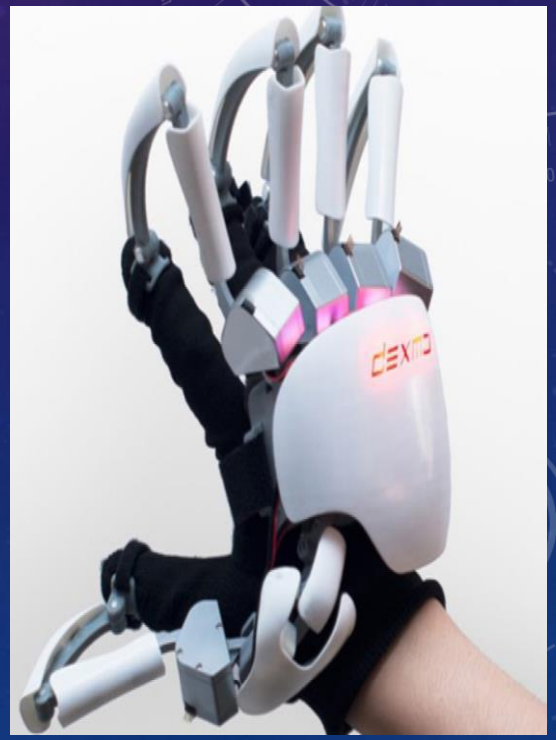
Manus VR:

- As VR pursues to develop more immersive with every new upgrade of hardware, peripheral creators are trying a thoughtful effort to cover the fact that you are using a controller.
- There are numerous gloves that need you to 'feel' virtual reality with your hands but Manus VR needs to plunge your whole arm.
- These gloves are designed to provide **full-body tracking** for motion capture and VR.

CONTD…

Dexmo VR:

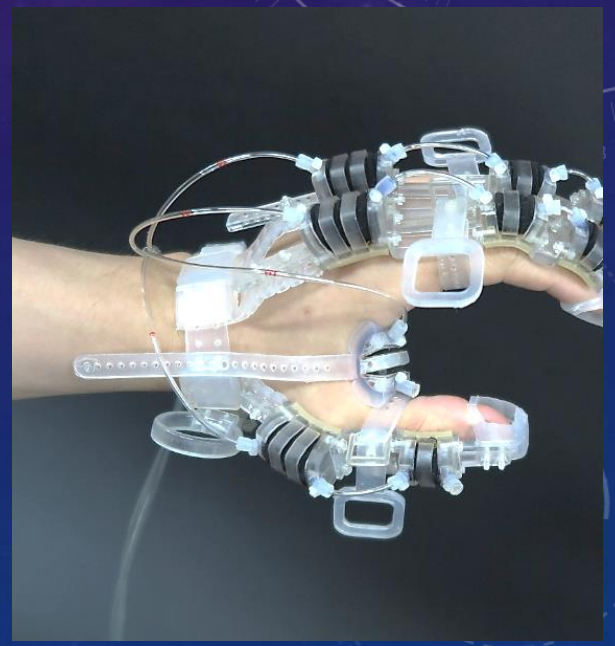
- From the tech of Dextra Robotics a different type of VR glove is presented.
- This type is exoskeletal, which means that the gluttons are on the external, very noticeable, and kind of bulky. If you need to have that spider-monster feel, they will assist.
- Dexmo works on a belief called force response.
- This fundamentally means that a slight motor performance as a spring, responding to force that is placed onto the fingers of the user who is wearing the VR glove.



CONTD…

ExoGlove:

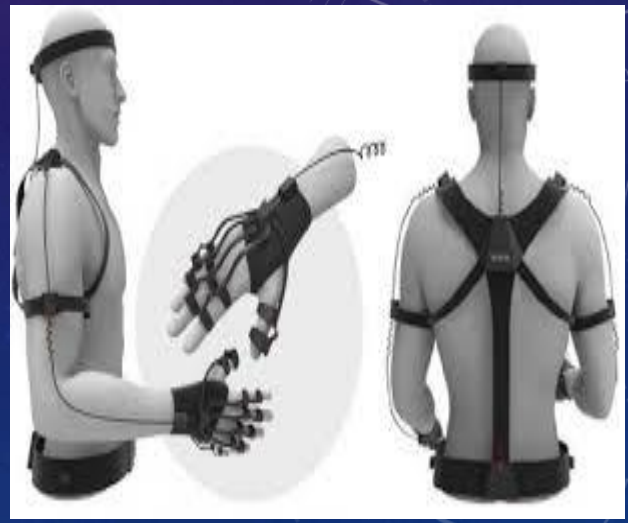
- ExoGlove is basically a wireless virtual reality attentive wearable product intended to be used as a means of supervising games and surroundings.
- The technology in this product uses the built in stifles in order to trail the movement of hands and fingers.
- The haptic response is then used to signify the virtual objects present in the scene.
- They are capable of giving a feel of touching something into the game, and it is very helpful in generating a much more immersive experience and closing towards reality.



CONTD…

Perception Neuron:

- Perception Neuron is a specialized gesture capture maneuver that can always be used for virtual reality controller skills as well.
- Three of the dissimilar sensors are being used (accelerometers, gyroscopes and also magnetometers) in order to determine the actions and placing of each of the hand.
- The drivers for the working are not needed for these gloves on any of the device, it is a simple plug and then play. So, this makes this product for a relaxed system that anybody can easily handle.



VIDEO BASED INPUT DEVICES

- Video input devices digitize images or video from the outside world into a computer.
- When choosing a video-based input device for virtual reality (VR), you can consider the trade-off between task-specific requirements and a widely applicable device.
- Video-based input devices such as cameras or sensors to capture the images or videos of the user or the environment and process them to extract information for VR interaction.

TYPES OF VIDEO-BASED INPUT DEVICES

- **Webcams**
- **Depth cameras**
- **360-degree cameras**
- **Stereo cameras**

WEBCAMS

- These are simple cameras that can be attached to a computer or a VR headset and can capture the user's face, head, or hand movements. Webcams can be used for facial recognition, expression analysis, gesture recognition, or eye tracking.

For example, a webcam can detect the user's smile and trigger a corresponding action in the VR environment.

DEPTH CAMERAS

- These are cameras that can measure the distance or depth of the objects in the scene using infrared light or structured light.
- Depth cameras can be used for body tracking, hand tracking, object recognition, or scene reconstruction.

For example, a depth camera can track the user's body posture and map it to a virtual avatar

360-DEGREE CAMERAS

- These are cameras that can capture the entire spherical view of the scene using multiple lenses or mirrors.
- 360-degree cameras can be used for creating panoramic videos, immersive videos, or live streaming.

For example, a 360-degree camera can record a video of a real-world location and play it back in VR.

STEREO CAMERAS

- These are cameras that have two or more lenses that are separated by a small distance, similar to human eyes.
- **Stereo cameras can create a sense of depth and perspective by capturing two slightly different images of the scene and combining them into a single image.**
- Stereo cameras can be used for 3D vision, 3D scanning, or 3D printing.

For example, a stereo camera can scan a real object and create a 3D model of it for VR.

3D MANUS & 3D SCANNER

- 3D Manus and 3D Scanner in virtual reality are two technologies that can be used to create and interact with 3D models in VR environments.
- 3D Manus is a VR glove that can track the hand movements and gestures of the user and translate them into VR actions.
- 3D Scanner is a device that can capture the shape and appearance of real-world objects and create digital 3D models of them.

CONTD…

- 3D Manus and 3D Scanner can be used together to create immersive and realistic VR experiences.
- For example, a user can scan a real object using a 3D Scanner and then manipulate it in VR using a 3D Manus glove.
- This can be useful for various applications, such as education, entertainment, art, design, engineering, etc..

VISUAL DEVICES FOR OUTPUT OF VIRTUAL REALITY

- Visual devices for output of virtual reality are devices that display the virtual environment to the user's eyes, creating a sense of immersion and presence.
- There are different types of visual devices for output of virtual reality, such as:
  - Head-mounted display(HMDs)
  - Projection Systems
  - Flat-screen displays

Projection Systems

- These are devices that use projectors to create a large image of the virtual environment on a wall, a screen, or a dome.
- Projection systems can provide a wider field of view than HMDs, allowing the user to see more of the virtual environment at once.
- Projection systems can also be used by multiple users at the same time, enabling collaborative or competitive VR experiences.
- However, projection systems require more space and equipment than HMDs, and they may not provide a full 360-degree view of the virtual environment.
- Examples of projection systems include CAVEs, Powerwalls, and Domes

Flat-screen displays

- These are devices that use monitors, televisions, or tablets to display the virtual environment on a flat surface.
- Flat-screen displays are the simplest and most common type of visual devices for output of virtual reality, as they can be easily connected to a computer or a console that runs the VR software.
- Flat-screen displays can also be used with other devices, such as motion controllers, cameras, or headphones, to enhance the VR experience.
- However, flat-screen displays do not provide a fully immersive experience, as they do not block the user's peripheral vision or track the user's head movements.
- Examples of flat-screen displays include desktop monitors, laptop screens, and mobile devices

Auditory devices

•There are different types of auditory devices for output of virtual reality, depending on the technology and the quality of the sound.

- •Headphones
- •Speakers
- •Bone conduction devices

Headphones

- These are devices that are worn over the user's ears and deliver sound directly to the user's ears.
- Headphones can provide a high-quality and immersive sound experience, as they can block out external noise and create a 3D sound effect.
- Headphones can be wired or wireless, and they can also have built-in microphones for communication.
- Examples of headphones include Oculus Rift headphones, HTC Vive headphones, and Sony PlayStation VR headphones

Speakers

- These are devices that emit sound from a fixed location, such as a wall, a ceiling, or a floor.
- Speakers can provide a wide and realistic sound field, as they can cover a large area and create a surround sound effect.
- Speakers can also be used by multiple users at the same time, enabling collaborative or competitive VR experiences.
- However, speakers may not provide a fully immersive sound experience, as they may not block out external noise or track the user’s head movements.
- Examples of speakers include CAVE speakers, Powerwall speakers, and Dome speakers

Bone conduction devices

- These are devices that transmit sound through the user's skull, rather than through the user's ears.
- Bone conduction devices can provide a unique and comfortable sound experience, as they do not cover the user's ears and allow the user to hear both the virtual and the real sounds.
- Bone conduction devices can also be useful for users who have hearing impairments or ear infections.
- Examples of bone conduction devices include Google Glass bone conduction speaker, and Damson Headbones headphones.

Haptic devices

- A haptic device is a device that can create an experience of touch by applying forces, vibrations, or motions to the user.
- Haptic devices are used for output of virtual reality to enhance the realism and immersion of the VR environment.
- Haptic devices can provide feedback for the user's actions, such as grasping, pushing, or pulling virtual objects.
- Haptic devices can also simulate the texture, shape, weight, and temperature of virtual objects.

Example:- Gloves, Exoskeletons,Vests

Vests

•These are devices that are worn on the user's torso and provide vibrotactile and thermal feedback for the user's body sensations.

•**Vests can also monitor the user's heart rate and breathing, creating a sense of biometric feedback for the user's emotions and health.**

•Vests can be used for feeling the impact, temperature, or mood of the VR environment.

Examples of vests include bHaptics, Woojer, and Teslasuit

bHaptics

Movement Capture Input Devices

•Movement capture theory in virtual reality (VR) is the study of how human's movements can be recorded, analyzed, and reproduced in a synthetic environment.

•It involves the use of sensors, cameras, software, and algorithms to track the motion of body parts, gestures, and expressions, and to map them onto a virtual avatar or character.

•Movement capture theory can be applied to various domains, such as entertainment, education, health, sports, and social interaction .

Contd…

- One of the challenges of movement capture theory is to achieve realistic and natural motion in VR, while avoiding errors, noise, and latency.
- Another challenge is to deal with the psychological and physiological effects of VR on the user, such as presence, immersion and motion sickness.
- Movement capture theory aims to address these challenges by developing methods and techniques that can improve the quality, accuracy, and efficiency of motion capture and rendering in VR.

Types of Movement Capture Input Devices

1) Controllers
2) Joysticks
3) IMUs
4) Gloves
5) Track Pad

Controllers

- These are handheld devices that allow users to interact with the virtual environment.
- They come in various shapes and sizes and can be used to simulate a wide range of actions, such as pointing, grabbing, and throwing.
- A VR **controller typically consists of buttons, triggers, thumbsticks, and sensors** that track user's hand movements and translate them into actions in the virtual world.

Contd…

- These controllers are designed to be lightweight and comfortable, allowing for extended use without causing fatigue or discomfort.
- The **buttons** on a VR controller are often used for basic interactions, such as selecting objects or navigating menus.
- **Triggers**, on the other hand, are usually used for more precise actions, like shooting a virtual gun or grabbing an object.
- **Thumbsticks** provide analog input, allowing for smooth and precise movement within the virtual environment.

Contd…

- In addition to these input methods, VR controllers often incorporate sensors that track the position and orientation of the controller in real-time.
- This tracking technology enables accurate and responsive interactions, making you feel like you are truly present in the virtual world.
- A well-designed controller will make you forget that you are holding a device, allowing users to fully immerse themself in the virtual world.
- The layout and placement of buttons and triggers should be intuitive and ergonomic.
- This allows for quick and effortless access to different functions, minimizing the need to look down or fumble around with the controller.

Key Features of Controller

- **Comfort and Ergonomics**
  - controllers with an ergonomic design, adjustable straps, and a comfortable grip that allows for extended use without discomfort.
- **Tracking Accuracy**
  - A high level of tracking accuracy is essential for precise and realistic interactions within the virtual environment.
  - The controller should accurately reflect your hand movements and translate them into the virtual world without any noticeable lag or delay.
  - Look for controllers with advanced tracking technologies such as optical or inside-out tracking for optimal accuracy.

Key Features of Controller

- **Battery Life**
  - Long battery life is another vital feature to consider when selecting a VR controller.
  - controllers with extended battery life that can power you through multiple sessions without the need for frequent recharging.

Examples of Controller

- VR Gun Controller
  - These controllers look and feel like guns, making them ideal for shooter games and military training.
- Meta Quest 2
  - These controllers allow you to interact with the virtual world using your hands.
- Valve Index controllers
  - Also known as Valve Knuckles Controllers, these controllers are designed to complement the Valve Index headset. They have finger tracking capabilities and are designed to be held in the player's hands.

Contd…

- HTC Vive controller
  - HTC's Vive headset has two controllers tracked in six degrees of freedom. One controller is usually the main pointing device, while the other can be used for auxiliary input.

TrackPad

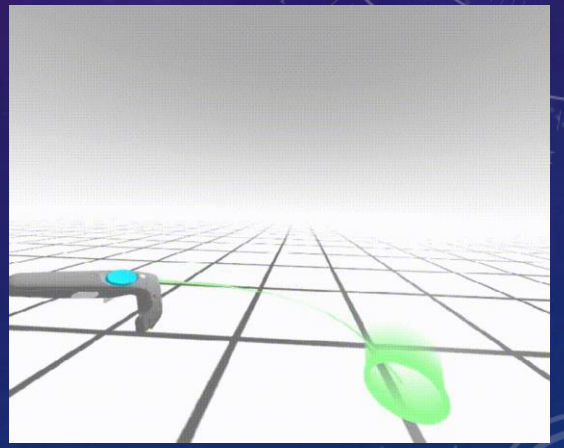
- A virtual trackpad can be used to interact with 2D content in virtual reality (VR).
- Trackpads can sense user inputs and provide feedback to blend virtual environments with the real world.
- A trackpad is a device that allows the user to control the movement of a cursor or a character in a virtual reality environment.
- It is usually a flat surface that detects the touch and motion of the user’s finger.

Contd…

•Some VR headsets and controllers have built-in trackpads, such as the HTC Vive and the Oculus Go.

•However, using a trackpad for VR locomotion may cause motion sickness or discomfort for some users, as it creates a mismatch between the visual and vestibular cues.

•Therefore, some VR developers and researchers are exploring alternative methods of VR locomotion, such as teleportation, walking in place, or using special devices like treadmills or bikes.



Teleportation

Joysticks

- A joystick is a type of VR controller **that allows the user to control the direction and speed of a virtual vehicle**, such as a plane, a car, or a spaceship.
- A joystick usually has a stick that can be tilted or rotated in different directions, and one or more buttons or triggers that can activate various functions.
- Using a joystick for VR locomotion may also reduce the risk of motion sickness or discomfort for some users, as it creates a more natural and consistent match between the visual and vestibular cues .

Contd…

- However, using a **joystick for VR locomotion may also limit the user's freedom of movement and exploration in the virtual world, as it restricts the user to a fixed position and orientation.**
- Therefore, some VR developers and researchers are experimenting with other methods of VR locomotion, such as hand gestures, eye tracking, or brain-computer interfaces .

Challenges in VR

- Virtual reality (VR) is an immersive technology that allows users to experience simulated environments through a headset and controllers. VR has many potential applications and benefits, such as entertainment, education, training, therapy, and social interaction. However, VR also faces some challenges that need to be overcome for its widespread adoption and development. Some Challenges in VR:
  1) User Experience
  2) Data Privacy
  3) Motion Sickness
  4) Social Interactions
  5) Use cases

Challenges in VR

- **User experience**:
  - VR devices and content need to provide a high-quality, comfortable, and realistic user experience.
  - This means improving the resolution, field of view, refresh rate, tracking, and interaction of VR headsets and controllers, as well as reducing the latency, weight, and cost of the devices.
  - VR content also needs to be engaging, diverse, and accessible for different users and preferences.

Challenges in VR

- **Data privacy**:
  - VR generates and collects a large amount of personal and sensitive data from users, such as their location, behavior, preferences, biometrics, and emotions.
  - This data can be used to improve the VR experience, but also poses risks of misuse, abuse, or theft by malicious actors.
  - VR users need to be aware of the data they share and the permissions they grant, and VR developers need to ensure the security, transparency, and consent of data collection and processing, as well as respect the user’s privacy and rights .

Challenges in VR

- **Social interaction**:
  - VR can enable social interaction and presence in virtual environments, allowing users to connect and collaborate with others across distances and contexts.
  - However, VR can also create social isolation and detachment from the real world, especially if users spend too much time or prefer VR over reality.
  - VR needs to balance the benefits and drawbacks of social VR, and foster positive and meaningful social experiences that enhance the user's well-being and relationships .

Challenges in VR

- **Motion sickness**:
  - Some users experience motion sickness or discomfort while using VR, which can be a barrier to its acceptance.
  - Motion sickness is caused by a mismatch between the visual and vestibular cues of motion, which can confuse the brain and make the user feel dizzy, nauseous, or unbalanced.
  - To avoid or reduce motion sickness, VR developers need to design content that minimizes sudden or unnatural movements, provides visual cues for orientation and stability, and adapts to the user's motion and preferences.

Challenges in VR

- **Use cases**:
  - VR needs to demonstrate its value and usefulness for various domains and scenarios, beyond entertainment and gaming.
  - VR has the potential to enhance learning, communication, collaboration, creativity, and productivity in various fields, such as education, health, tourism, manufacturing, and art.
  - However, VR needs to prove its effectiveness, efficiency, and affordability compared to other methods and technologies, as well as address the ethical, legal, and social implications of its use.