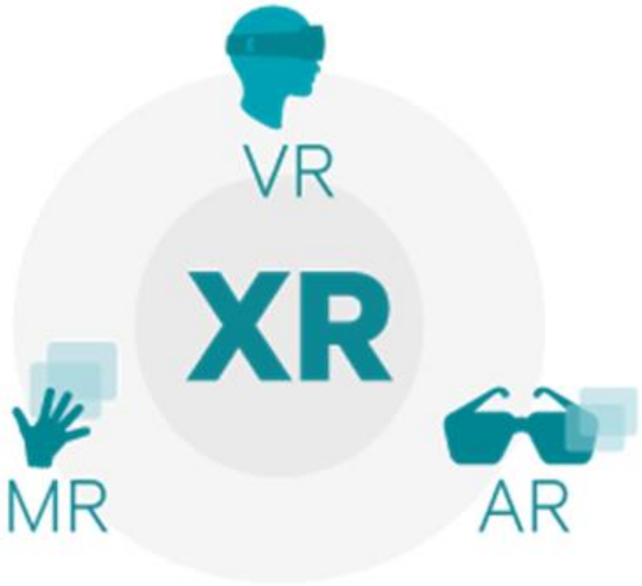


CSPE 51 – Augmented and Virtual Reality

B.Tech. (CSE) – III yr – A & B Sections

Faculty - Dr. M. Sridevi, AP/ CSE

Course Objectives

- To know basic concepts of virtual reality
- To understand visual computation in computer graphics
- To understand interaction between system and computer
- To know application of VR in Digital Entertainment
- To know basic concepts of augmented reality

Course Contents

- UNIT I Introduction of Virtual Reality: Fundamental Concept and Components of Virtual Reality - Primary Features and Present Development on Virtual Reality - Multiple Models of Input and Output Interface in Virtual Reality: Input - Tracker - Sensor - Digital Glove - Movement Capture - Video-based Input - 3D Menus & 3DScanner – Output - Visual /Auditory / Haptic Devices.
- UNIT II Visual Computation in Virtual Reality: Fundamentals of Computer Graphics - Software and Hardware Technology on Stereoscopic Display - Advanced Techniques in CG: Management of Large Scale Environments & Real Time Rendering.
- UNIT III Interactive Techniques in Virtual Reality: Body Track - Hand Gesture - 3D Menus - Object Grasp. Development Tools and Frameworks in Virtual Reality: Frameworks of Software Development Tools in VR. X3D Standard; Vega - MultiGen - Virtools.

Course Contents – Contd…

- UNIT IV Application of VR in Digital Entertainment: VR Technology in Film & TV Production - VR Technology in Physical Exercises and Games - Demonstration of Digital Entertainment by VR.
- UNIT V Augmented and Mixed Reality: Taxonomy - technology and features of augmented reality - difference between AR and VR - Challenges with AR - AR systems and functionality - Augmented reality methods - visualization techniques for augmented reality - wireless displays in educational augmented reality applications - mobile projection interfaces - marker-less tracking for augmented reality - enhancing interactivity in AR environments - evaluating AR systems.

Course

- Upon completion of this course, the students will be able to:
- Provide opportunity to explore the research issues in Augmented Reality and Virtual Reality (AR & VR)
- Know the basic concept and framework of virtual reality
- Know the computer-human interaction

Books

Text Books

1. Burdea, G. C., P. Coffet., “Virtual Reality Technology”, Second Edition, Wiley-IEEE Press, 2003/2006
2. Alan B. Craig, “Understanding Augmented Reality, Concepts and Applications”, Morgan Kaufmann, 2013.

Reference Books

1. Alan Craig, William Sherman, Jeffrey Will, “Developing Virtual Reality Applications, Foundations of Effective Design”, Morgan Kaufmann, 2009.

Source

- Image and Video source - from the intranet and text books

Introduction

- Devices used
- What is AR, VR, MR, XR?
- Applications
- Reality Vs Virtual reality

Devices used in Reality Technology

	VR	AR/MR
PC	 VIVE	 CINOPTICS
Standalone	 oculus	 magic leap
Smartphone	 SAMSUNG Gear VR	 IKEA

What is AR?

Augmented Reality (AR) is a live, direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.

AR exists on top of our own world it provides as much freedom as you are given within your normal life. AR utilizes your existing reality and adds to it utilizing a device of some sort.

Mobile and tablets are the most popular mediums of AR now, through the camera, the apps put an overlay of digital content into the environment. Custom headsets are also being used.

Popular AR examples : Pokemon Go and Snapchat’s new AR bitmojis.

Video : AR Examples

https://www.youtube.com/watch?v=2sj2iQyBTQs

What is VR?

- **Virtual Reality (VR)** is an immersive experience also called a computer-simulated reality.
- It refers to computer technologies using reality headsets to generate the realistic sounds, images and other sensations that replicate a real environment or create an imaginary world.
- VR is a way to immerse users in an entirely virtual world. A true VR environment will engage all five senses (taste, sight, smell, touch, sound), but it is important to say that this is not always possible.
- Gaming industry uses this technology into more practical applications.
- The market and the industry are still excited about this tech trend and further progress is expected in the near future.

Video : VR Example

https://www.youtube.com/watch?v=DfUUnp6Z_wc

What is MR?

- **Mixed Reality (MR),** sometimes referred to as hybrid reality, is the merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time.
- It means placing new imagery within a real space in such a way that the new imagery is able to interact, to an extent, with what is real in the physical world we know.
- The key characteristic of MR is that the synthetic content and the real-world content are able to react to each other in real time.

Video : MR Example

https://virsabi.com/mixed-reality/

What is XR?

- **Extended Reality (XR)** refers to all real-and-virtual combined environments and human-machine interactions generated by computer technology and wearables.
- Extended Reality includes all its descriptive forms like the Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR).
- In other words, XR can be defined as an umbrella, which brings all three Reality (AR, VR, MR) together under one term, leading to less public confusion. Extended reality provides a wide variety and vast number of levels in the Virtuality of partially sensor inputs to Immersive Virtuality.

Video :
AR, VR, MR, XR
Applications & Challenges

https://www.youtube.com/watch?v=2ZMg0mfEw-k

Applications

- Military
- Health care
- Education
- Visualization
- Entertainment

Challenges

- Device size and price
- High computing requirement
- Low latency

Advantages and Disadvantages of VR

Advantages

- Virtual reality creates a realistic world.
- It enables user to explore places.
- Through Virtual Reality user can experiment with an artificial environment.
- Virtual Reality make the education more easily and comfort.

Disadvantages

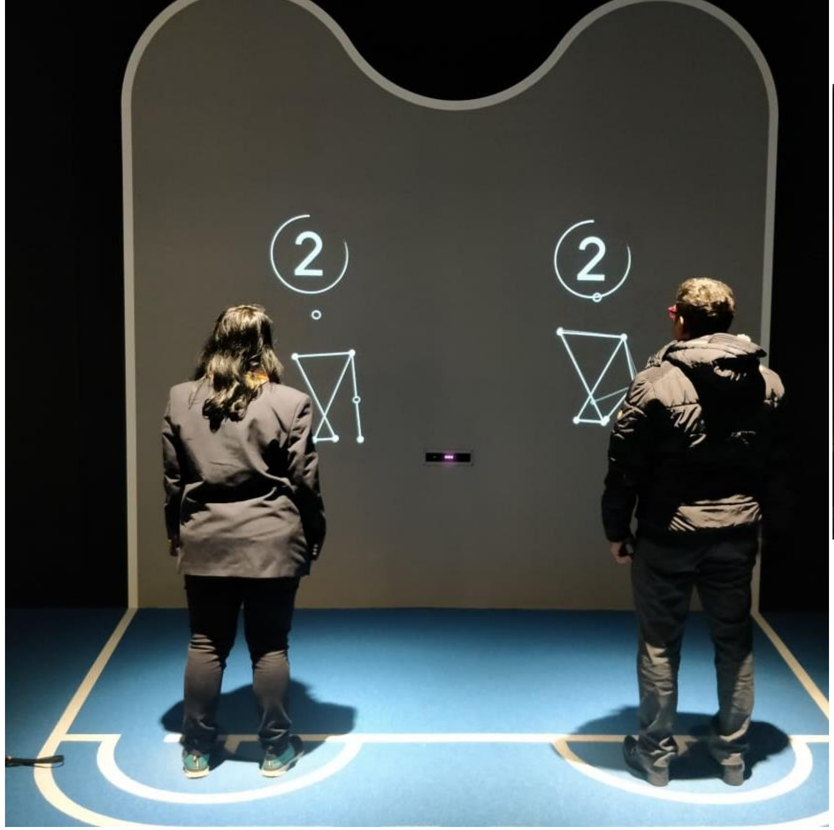
- The equipments used in virtual reality are very expensive.
- It consists of complex technology.
- In virtual reality environment we cant move by our own like in the real world.

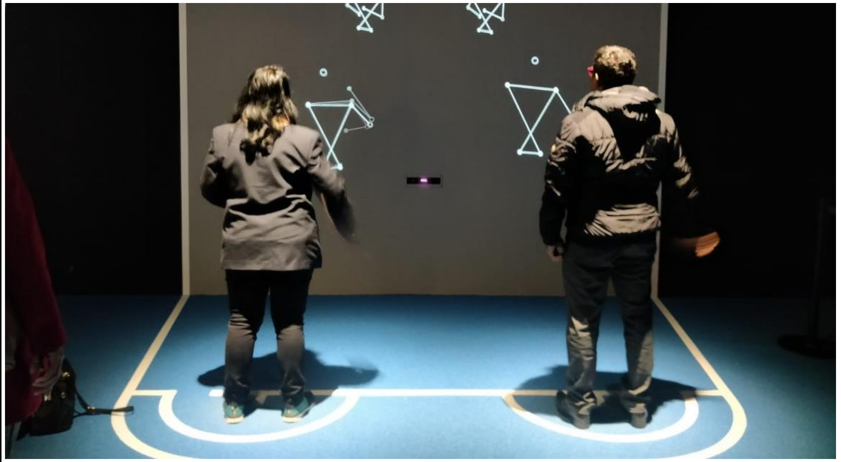
Tools

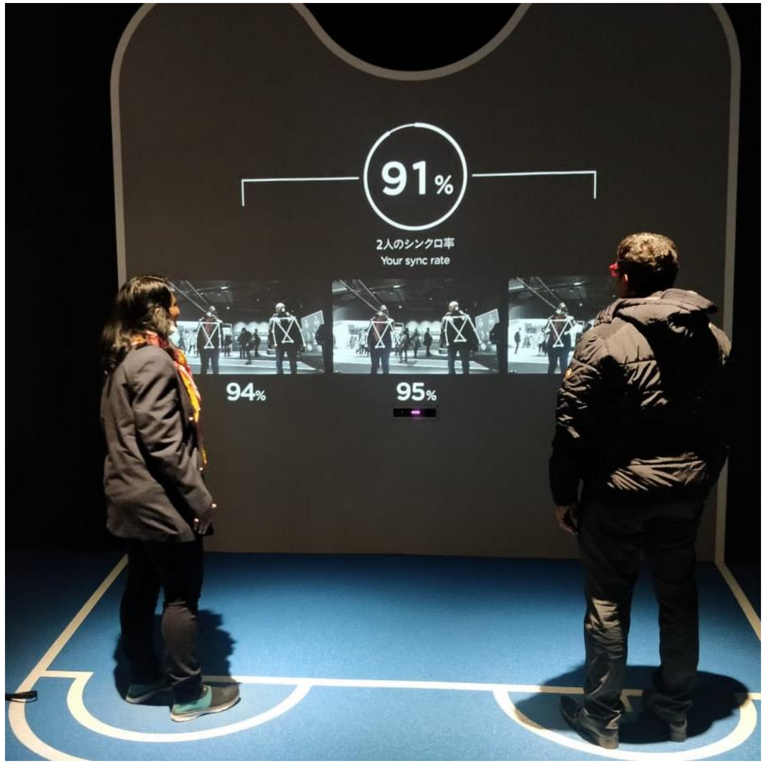
- Unity
- Unreal Engine 4
- Cryengine
- 3d Max
- Maya
- Many cloud-based tools available
- X3D
- Vega MultiGen
- Virtools

Japan - Photos

- JAXA Lab







Japan - Photos and Videos

Olympic Museum - https://www.youtube.com/watch?v=-_t6Kt2VB_Y

Unit – 1

Introduction of Virtual Reality: Fundamental Concept and Components of Virtual Reality - Primary Features and Present Development on Virtual Reality - Multiple Models of Input and Output Interface in Virtual Reality: Input - Tracker - Sensor - Digital Glove - Movement Capture - Video-based Input - 3D Menus & 3DScanner – Output - Visual /Auditory / Haptic Devices.

Introduction to VR

- **Virtual reality (VR)** - Computer simulation that creates an image of a world that appears to our senses in much the same way we perceive the real world, or "physical" reality.
- In order to convince the brain that the synthetic world is authentic, the computer simulation monitors the movements of the participant and adjusts the sensory display or displays in a manner that gives the feeling of being immersed or being present in the simulation.
- The term "virtual world" does not only refer specifically to virtual reality worlds. It can also be used to refer to the content of other media, such as novels, movies, and other communication conventions.

Types of VR

- Fully Immersive
- Non- Immersive
- Semi - Immersive

Fully-immersive

- 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.
- This type of VR has been commonly adapted for gaming and other entertainment purposes, but usage in other sectors, namely education, is increasing now as well. The possibilities for VR usage are endless.

Immersive Virtual Reality

Immersion into virtual reality is a perception of being physically present in a non-physical world.

Elements of virtual environments that increase the immersiveness of the experience:

1. Continuity of surroundings
2. Conformance to human vision
3. Freedom of movement
4. Physical interaction
5. Physical feedback

Non-immersive

- Non-immersive virtual experiences are often overlooked as a virtual reality category because it’s already so commonly used in everyday life. 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.

Non-Immersive Virtual Reality

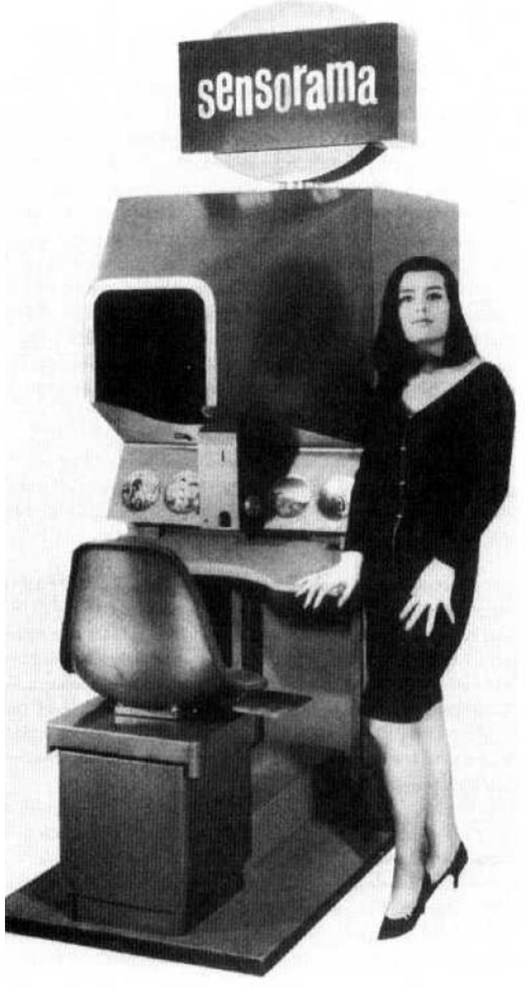
- Large display, but doesn't surround the user.

Semi-immersive

- Semi-immersive virtual experiences provide users with a partially virtual environment. It will still give users the perception of being in a different reality when they focus on the digital image, but also allows users to remain connected to their physical surroundings. Semi-immersive technology provides realism through through 3D graphics, a term known as vertical reality depth. More detailed graphics result in a more immersive feeling.
- This category of VR is used often for educational or training purposes and relies on high-resolution displays, powerful computers, projectors or hard simulators that partially replicate design and functionality of functional real-world mechanisms.

Primary Features and Present Development on Virtual Reality

- Virtual reality is not a new invention, but dates back more than 60 years.
- In 1962, U.S. Patent #3,050,870 was issued to Morton Heilig for his invention entitled Sensorama Simulator, which was the first virtual reality video arcade.
- Figure shows early virtual reality workstation has three-dimensional (3D) video feedback (obtained with a pair of side-by-side 35-mm cameras), motion, color, stereo sound, aromas, wind effects (using small fans placed near the user's head), and a seat that vibrated. It was thus possible to simulate a motorcycle ride through New York, where the "rider" sensed the wind and felt the pot-holes of the road as the seat vibrates. The rider could even smell food when passing by a store.



- Sutherland's vision of an "ultimate display" to the virtual world was not limited to graphics. In 1965 he predicted that the sense of touch (or haptics) would be added in order to allow users to feel the virtual objects. This idea was made reality by Frederick Brooks, Jr., and his colleagues at the University of North Carolina at Chapel Hill.
- By 1971 these scientists demonstrated the ability to simulate two-dimensional continuous force fields associated with molecular docking forces [Batter and Brooks, 1971]. Later they simulated three-dimensional collision forces using a surplus robotic arm normally used in nuclear material handling.

- Most of today's haptic technology is based on miniature robotic arms. The military was very eager to test the new digital simulators, since they hoped to replace very expensive analog ones. Flight simulators were hardware designed for a particular airplane model. When that airplane became obsolete, so did its simulator, and this was a constant drain of funds. If the simulation could be done in software on a general-purpose platform, then a change in airplane models would only require software upgrades.
- Much research went on in the 1970s and early 1980s on flight helmets and modem simulators for the military, but much of this work was classified and was not published. This changed when funds for defense were cut and some researchers migrated to the civilian sector.

- The National Aeronautics and Space Agency (NASA) was another agency of the American government interested in modern simulators. It needed simulations for astronaut training, as it was difficult or impossible to otherwise recreate conditions existing in outer space or on distant planets.
- In 1981, on a very small budget, NASA created the prototype of a liquid crystal display (LCD)-based HMD, which they named the Virtual Visual Environment Display (VIVED). NASA scientists simply disassembled commercially available Sony Watchman TVs and put the LCDs on special optics. These optics were needed to focus the image close to the eyes without effort. The majority of today's virtual reality head-mounted displays still use the same principle. NASA scientists then proceeded to create the first virtual reality system by incorporating a DEC PDP 11-40 host computer, a Picture System 2 graphics computer (from Evans and Sutherland), and a Polhemus noncontact tracker. The tracker was used to measure the user's head motion and transmit it to the PDP 11-40. The host computer then relayed these data to the graphics computer, which calculated new images displayed in stereo on the VIVED.

- In 1985 the project was joined by Scott Fisher, who integrated a new kind of sensing glove into the simulation. The glove was developed earlier by Thomas Zimmerman and Jaron Lanier as a virtual programming interface for nonprogrammers.
- By 1988 Fisher and Elizabeth Wenzel created the first hardware capable of manipulating up to four 3D virtual sound sources. These are sounds that remain localized in space even when the user turns his or her head. This represented a very powerful addition to the simulation. The original VIVED project became VIEW (for Virtual Interface Environment Workstation) and the original software was ported to a newer HewlettPackard 9000, which had sufficient graphics performance to replace the wireframe rendering used in VIVED with more realistic flat-shaded surfaces.

- With all the afore mentioned technological developments, scientific exchange of information among the small group of specialists of the time followed. France was one of the first countries to organize a major international conference on the subject, held in Montpellier in March 1992. The name of this conference was Interfaces for Real and Virtual Worlds, and it drew hundreds of papers and many vendors. Later the same year the United States organized the first conference on Medicine Meets Virtual Reality. In San Diego, about 180 medical practitioners met with 60 scientists and engineers to discuss the great potential of virtual reality as a tool for medicine. In September 1993 the world's largest professional society, the Institute of Electrical and Electronics Engineers (IEEE), organized its first VR conference in Seattle. Virtual reality had become part of the mainstream scientific and engineering community.

Present Development in VR

- VR has been used in different fields, as for gaming, military training, architectural design, education, learning and social skills training, simulations of surgical procedures, assistance to the elderly or psychological treatments are other fields in which VR is bursting strongly .
- There are many possibilities that allow the use of VR as a stimulus, replacing real stimuli, recreating experiences, which in the real world would be impossible, with a high realism. This is why VR is widely used in research on new ways of applying psychological treatment or training, for example, to problems arising from phobias (agoraphobia, phobia to fly, etc.) . Or, simply, it is used like improvement of the traditional systems of motor rehabilitation, developing games that ameliorate the tasks. More in detail, in psychological treatment, Virtual Reality Exposure Therapy (VRET) has showed its efficacy, allowing to patients to gradually face fear stimuli or stressed situations in a safe environment where the psychological and physiological reactions can be controlled by the therapist.

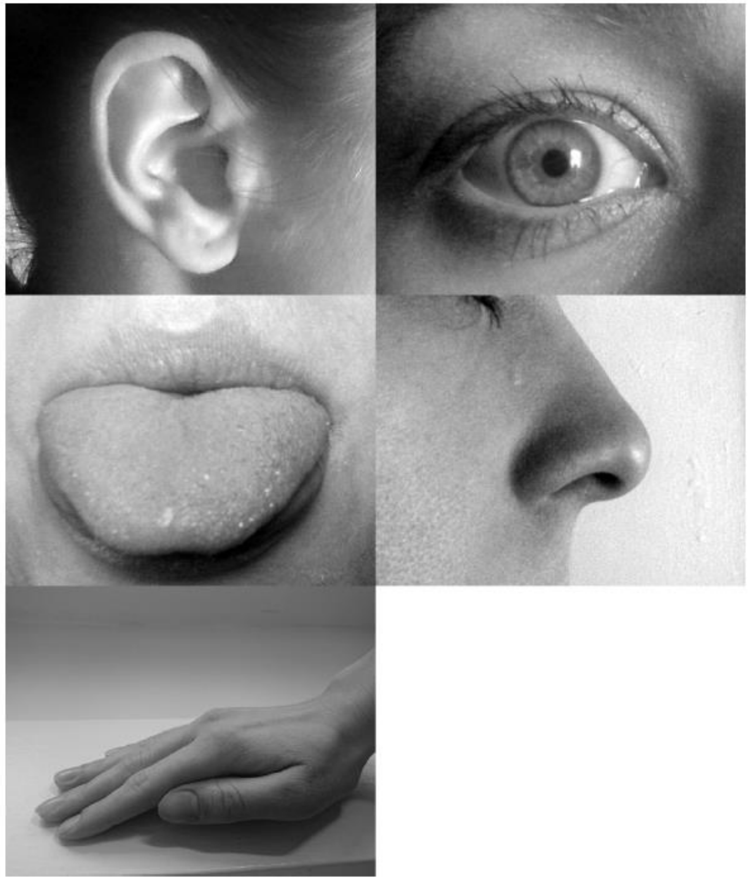
Video

- https://www.smlease.com/entries/technology/what-is-virtual-reality/
- https://www.youtube.com/watch?v=tXIcG3B7CsY
- https://www.youtube.com/watch?v=4APerjQYORk&t=39s

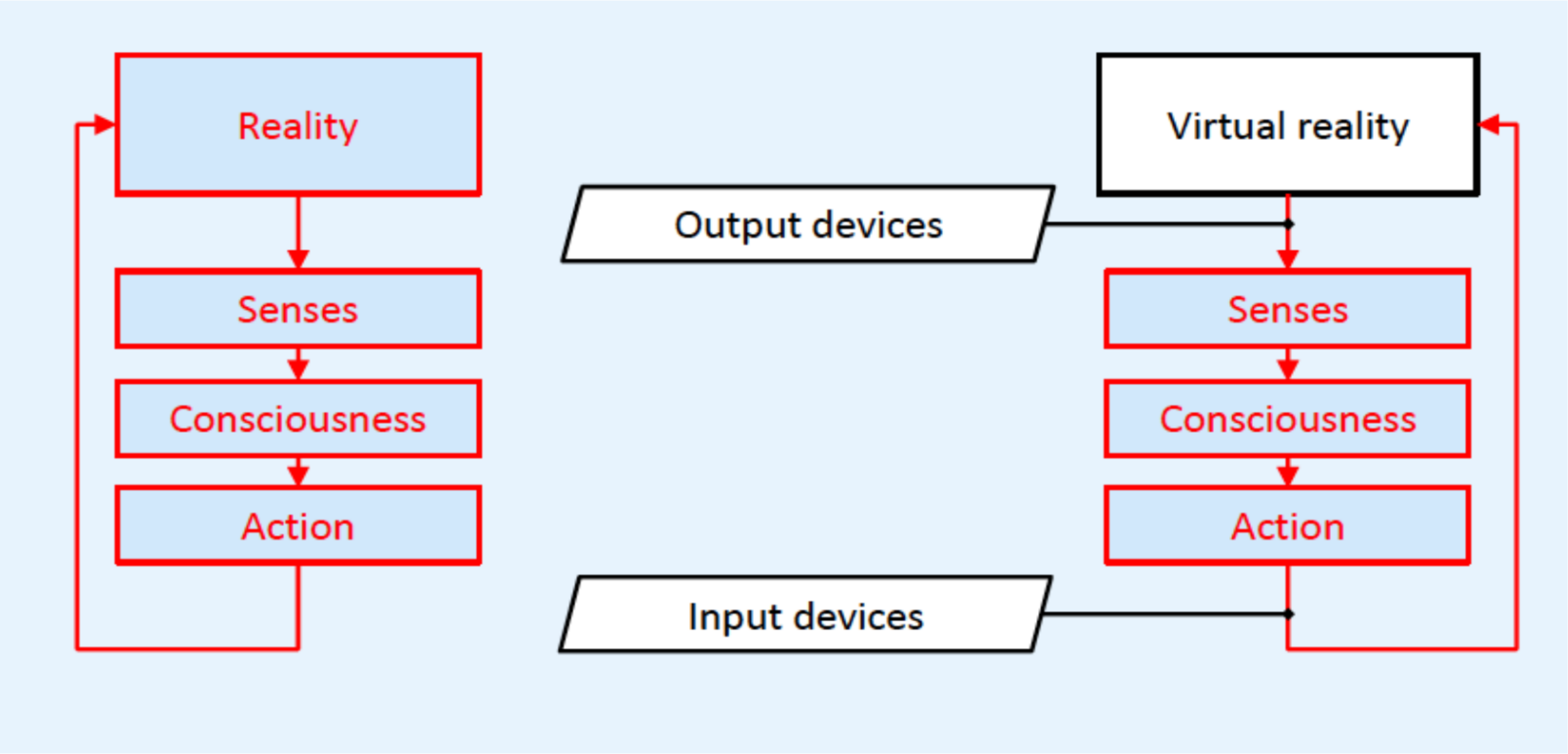
Fundamental Concept of VR

How do We Perceive Reality?

- We understand the world through our senses:
  - Sight, Hearing, Touch, Taste, Smell (and others..)
- Two basic processes:
  - Sensation – Gathering information
  - Perception – Interpreting information



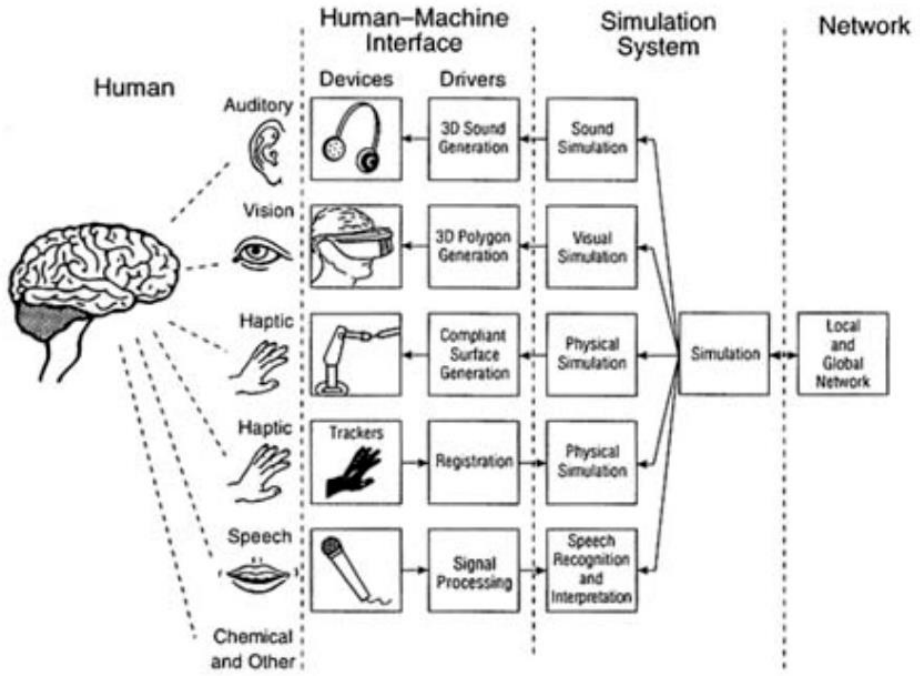
Reality vs. Virtual Reality



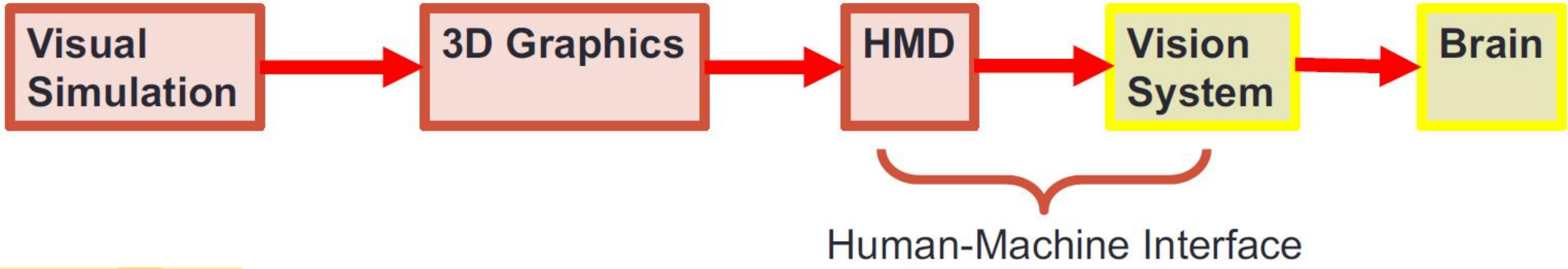
- In a VR system there are input and output devices between human perception and action

Using Technology to Stimulate Senses

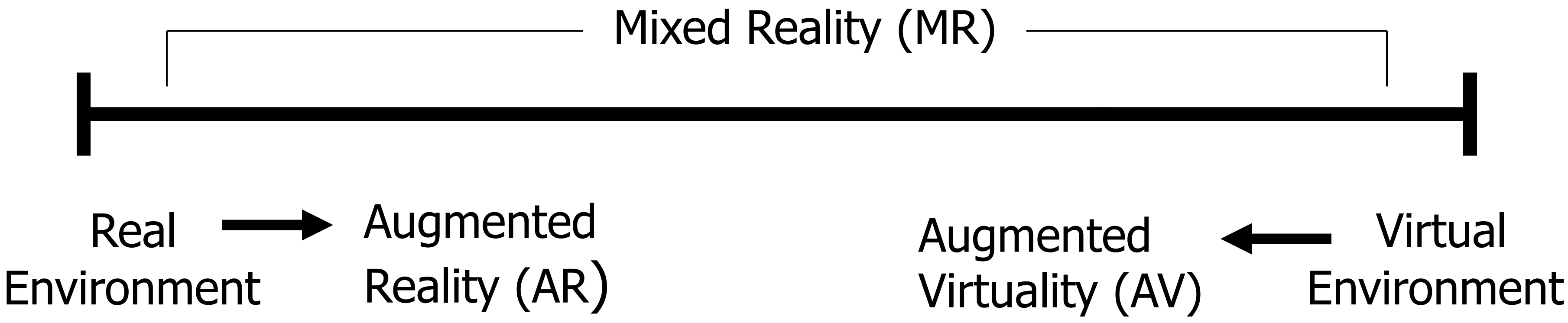
- Simulate output
  - E.g. simulate real scene
- Map output to devices
  - Graphics to HMD
- Use devices to stimulate the senses
  - HMD stimulates eyes



Example: Visual Simulation



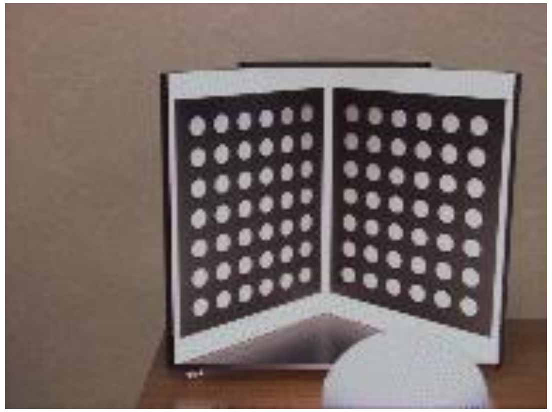
Milgram's Reality-Virtuality Continuum

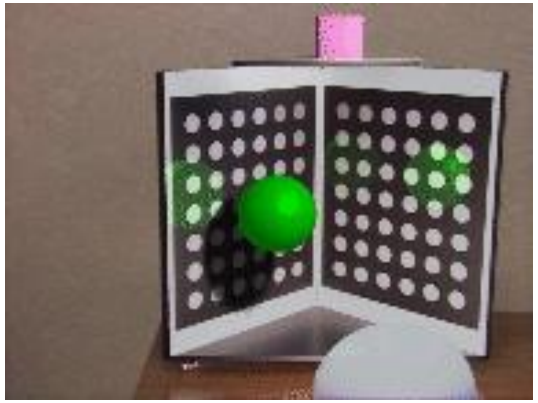


Milgram coined the term "Augmented Virtuality" to identify systems which are mostly synthetic with some real world imagery added such as texture mapping video onto virtual objects.

Combining the Real and Virtual Worlds

- Precise models
- Locations and optical properties of the viewer (or camera) and the display
- Calibration of all devices
- To combine all local coordinate systems centered on the devices and the objects in the scene in a global coordinate system
- Register models of all 3D objects of interest with their counterparts in the scene
- Track the objects over time when the user moves and interacts with the scene





Realistic Merging

Requires:

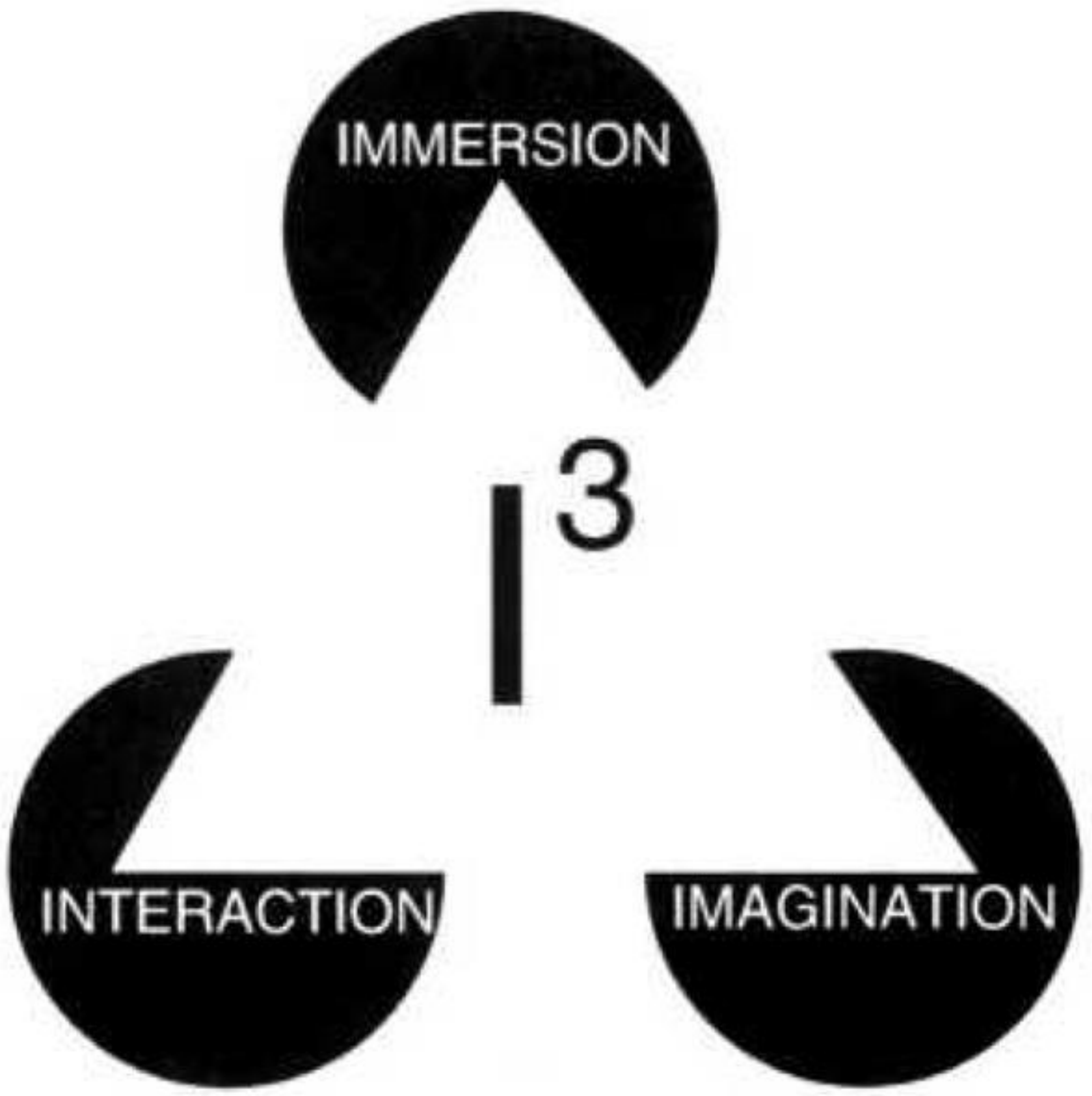
- Objects to behave in physically plausible manners when manipulated
- Occlusion
- Collision detection
- Shadows

Types of reality:

- AR, VR, MR, XR

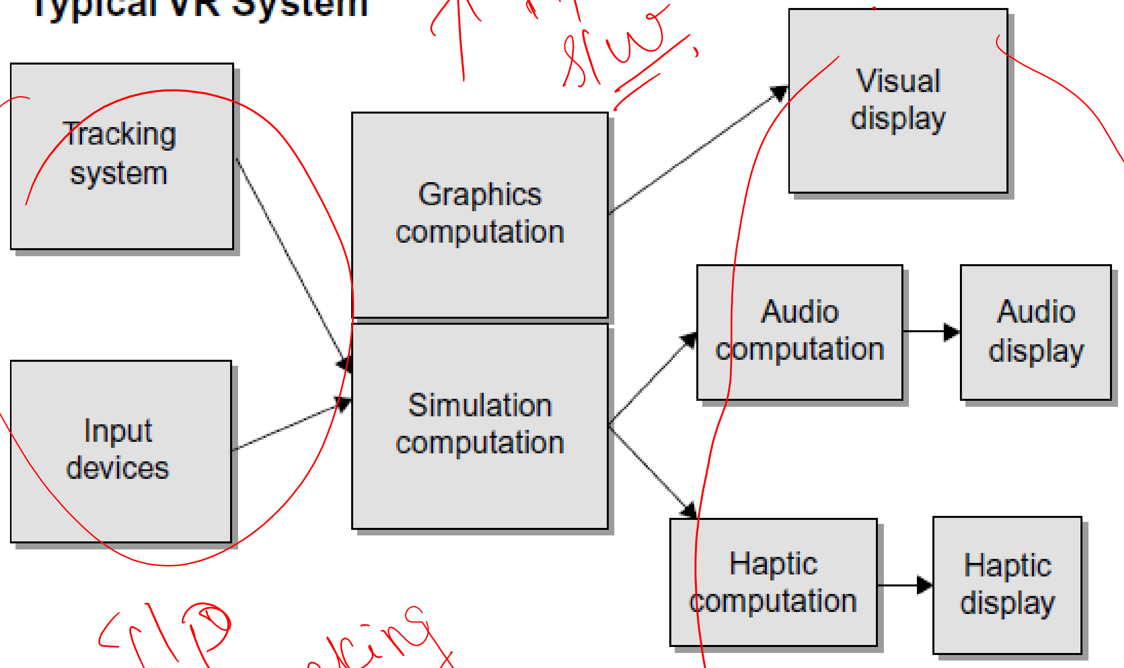
Elements of VR

3 I's in VR



Components of Virtual Reality

Typical VR System



Computer H/w S/w

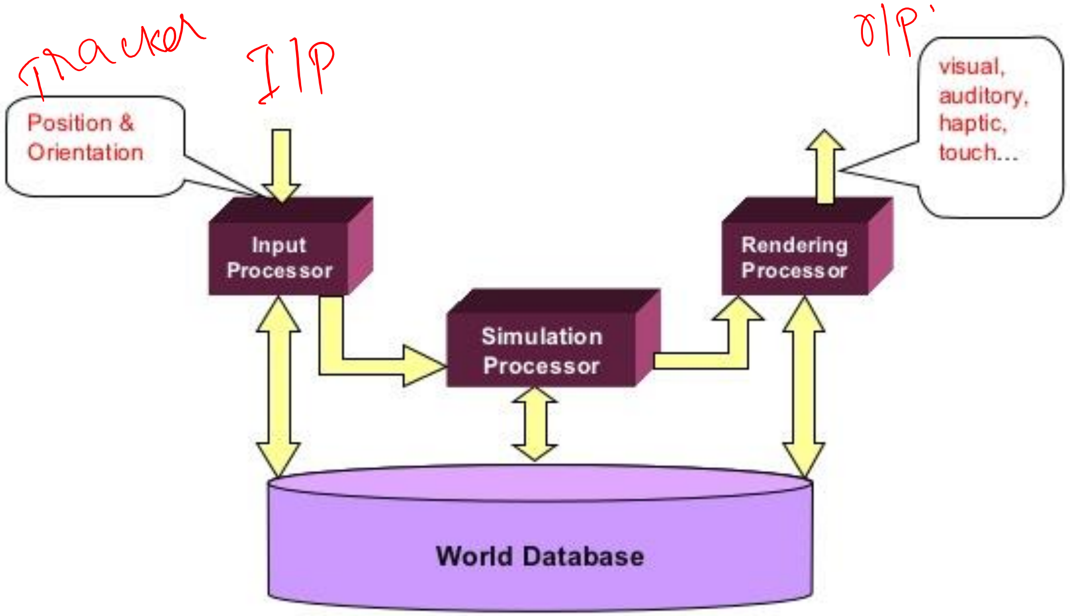
O/p / display

I/p & tracking

Components of VR

Components of VR System:

Input Processor, Simulation Processor, Rendering Processor and World Database.



VR Input Devices

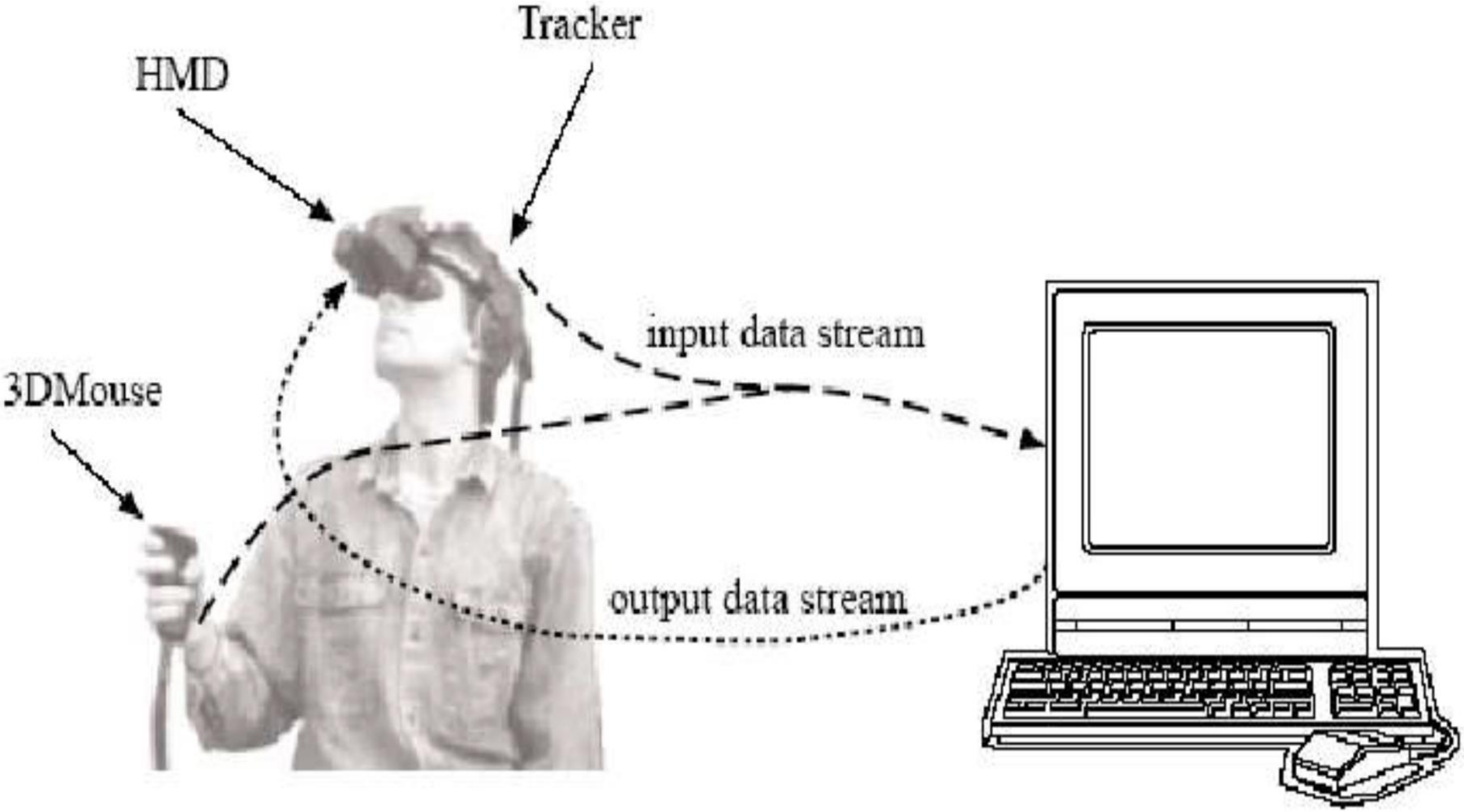
Hand Input Devices

- Devices that integrate hand input into VR
- World-Grounded input devices
  - Devices fixed in real world (e.g. joystick)
- Non-Tracked handheld controllers
  - Devices held in hand, but not tracked in 3D (e.g. xbox controller)
- Tracked handheld controllers
  - Physical device with 6 DOF tracking inside (e.g. Vive controllers)
- Hand-Worn Devices
  - Gloves, EMG bands, rings, or devices worn on hand/arm
- Bare Hand Input
  - Using technology to recognize natural hand input

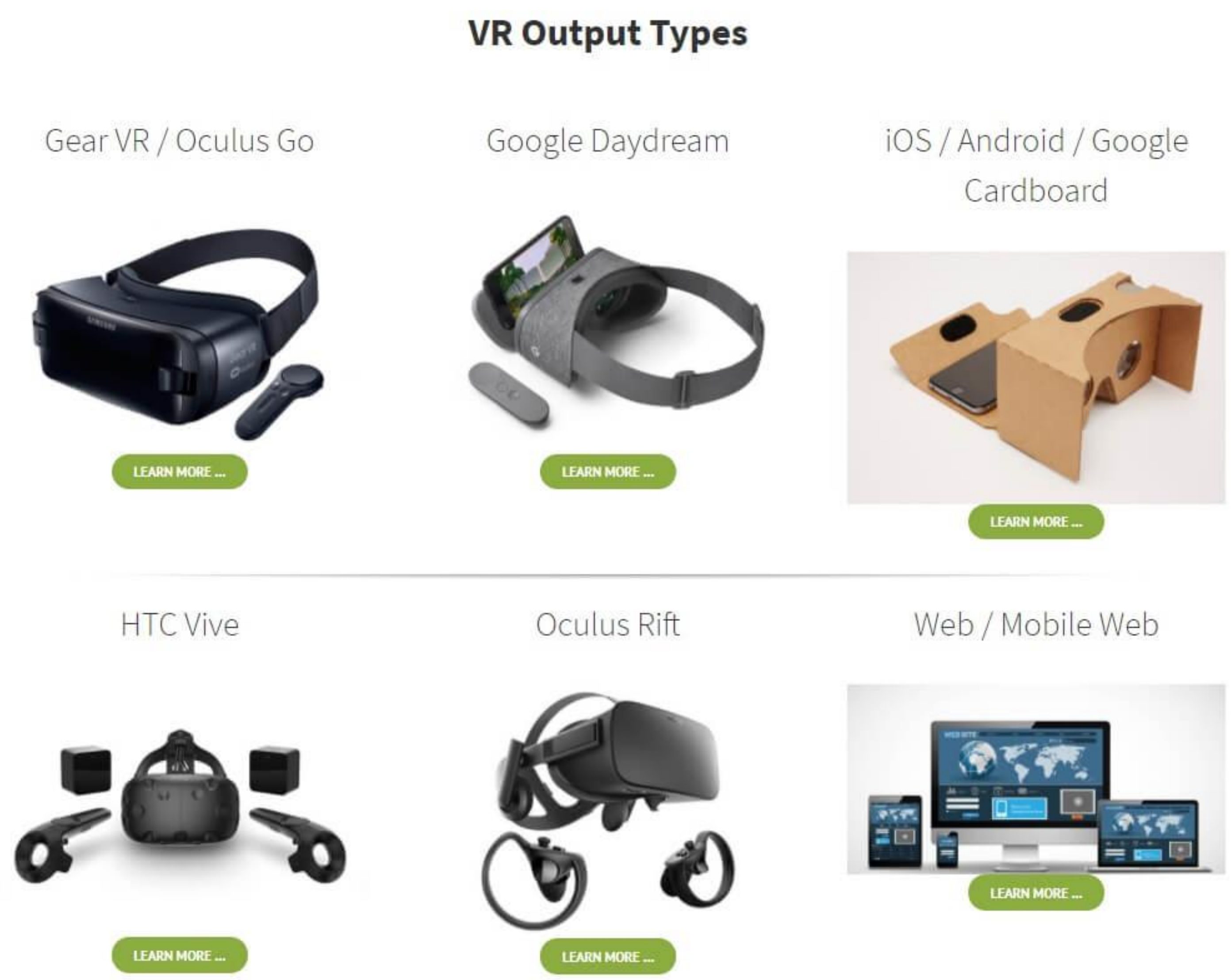
VR Input Devices

Non-Hand Input Devices

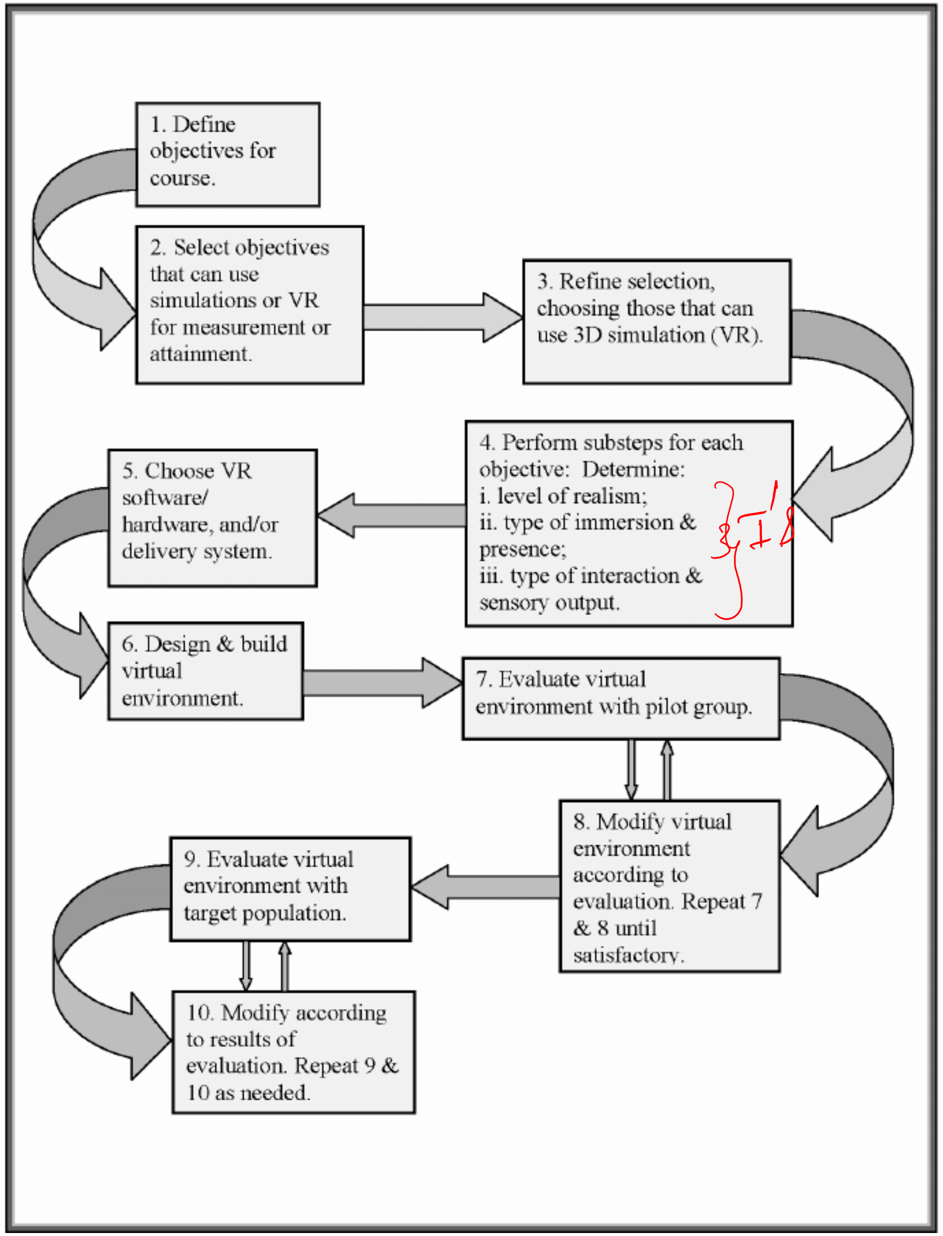
- Capturing input from other parts of the body
- Head Tracking
  - Use head motion for input
- Eye Tracking
  - Largely unexplored for VR
- Microphones
  - Audio input, speech
- Full-Body tracking
  - Motion capture, body movement


Tracker
HMD
input data stream
3DMouse
output data stream

VR output Devices



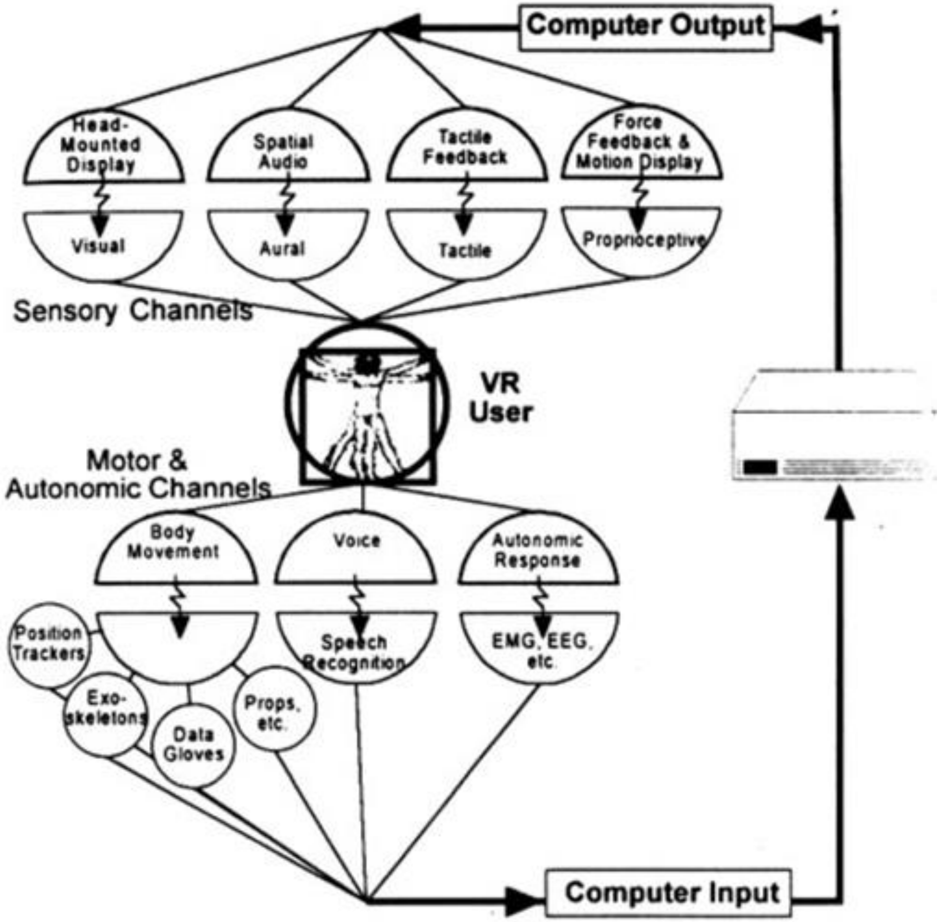
Steps involved in VR



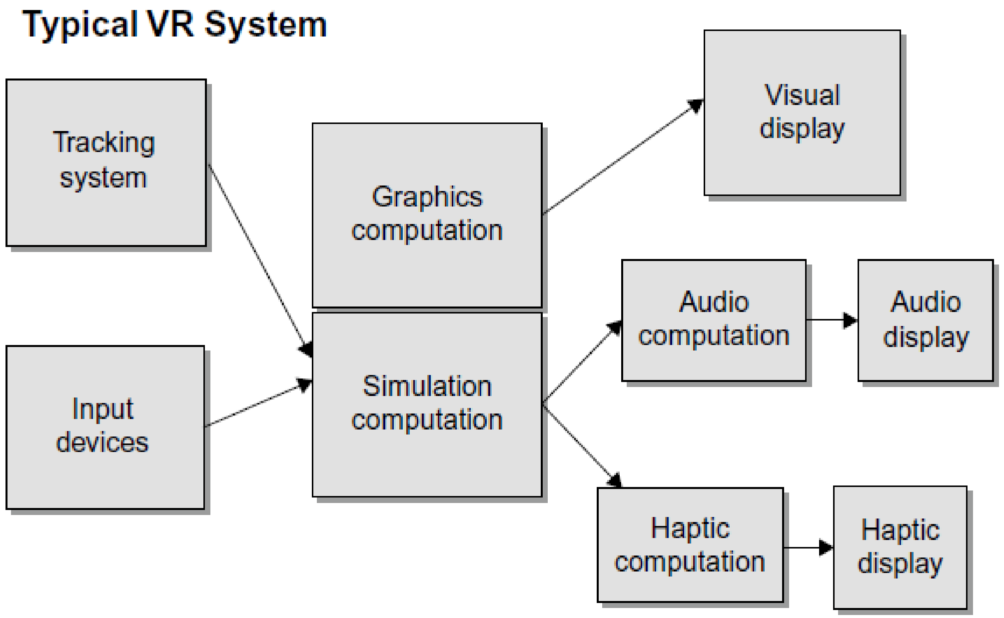
Video - Application

- https://www.youtube.com/watch?v=iofuy7tTiYE

Mapping Between Input and Output



Hardware Components used in VR System



Input Devices & User Tracking	Computation	Output / Display Devices
Mouse	Computer Engine	Visual display
Data glove, etc..	Graphic Engine	Aural display
Tracker		Haptic display
		Sensory display

Computation

Computer engine:

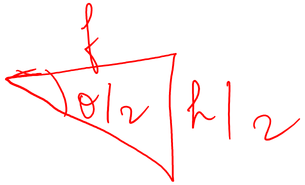
- Responsible for calculating the physical behaviour of the Virtual World
- Render the state of the world into visual, aural, haptic, …

Graphics engine:

- Enough computation power to perform the virtual world physical simulation calculations, graphic rendering platform.

OS:

- Perform Multithreaded operations



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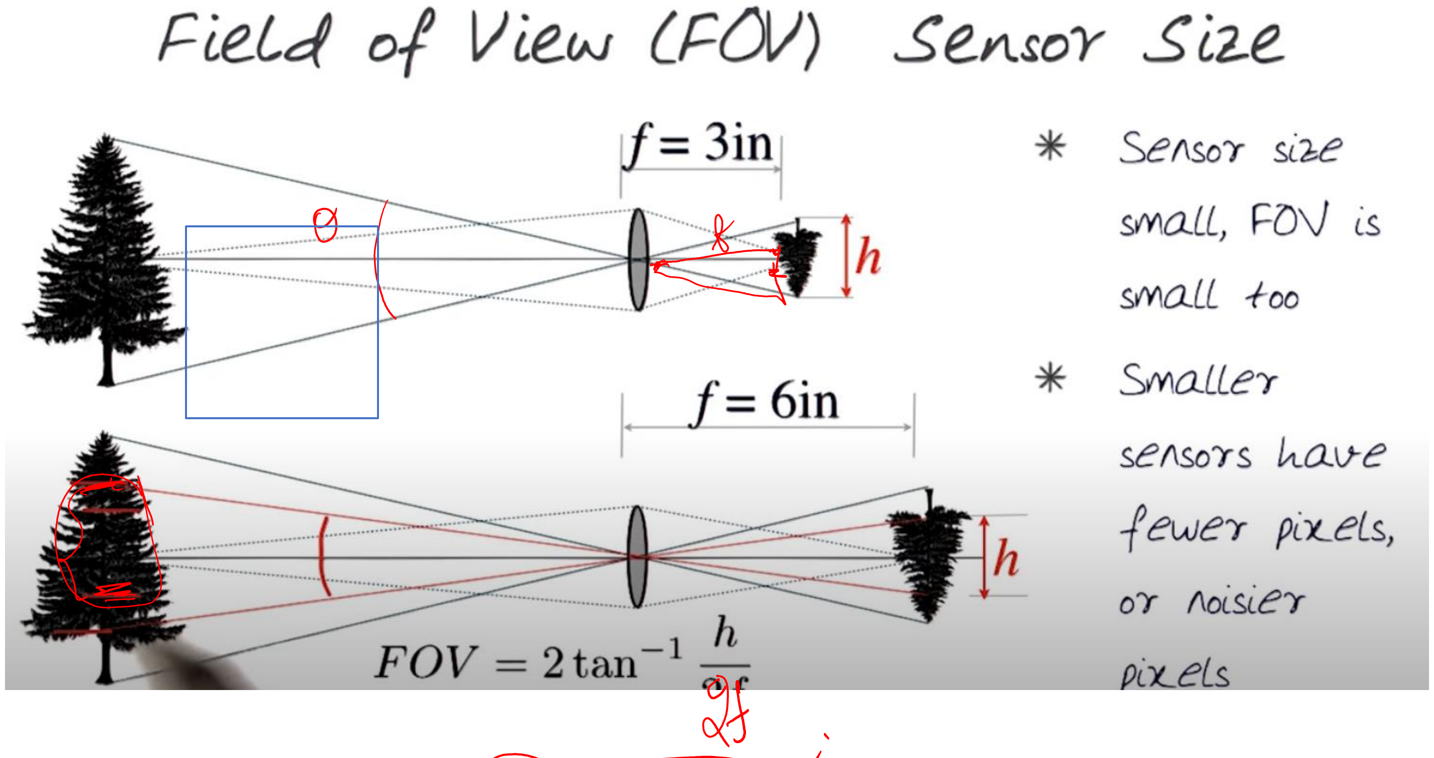
Field of View (FoV)



https://www.youtube.com/watch?v=pUuAx_zFnEk

FoV & FoR

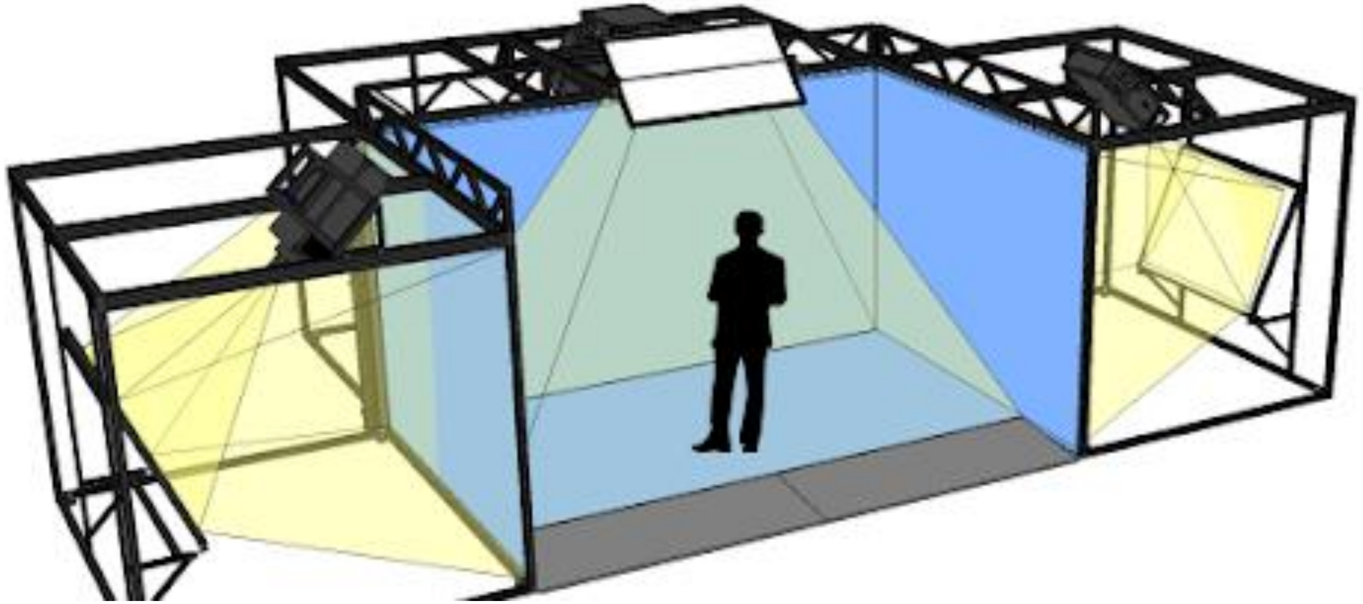
Field of View (FoV) and Field of Regard (FoR)

- https://www.youtube.com/watch?v=qgF2mZTPkYs
- https://www.youtube.com/watch?v=y0bOi3kVIBs

Display Devices

Visual display

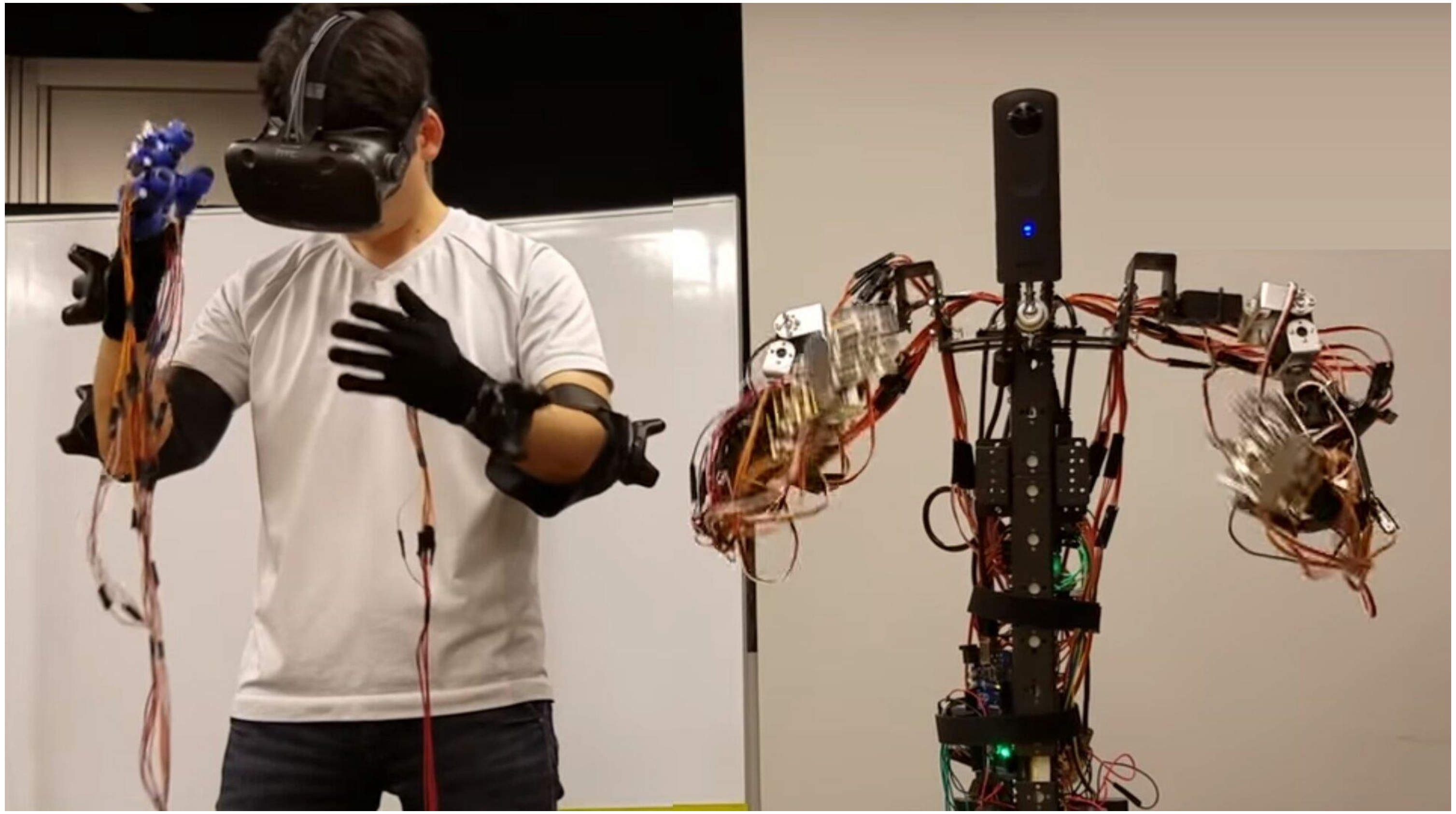
- Stationary display
- Head based display
- Hand based display

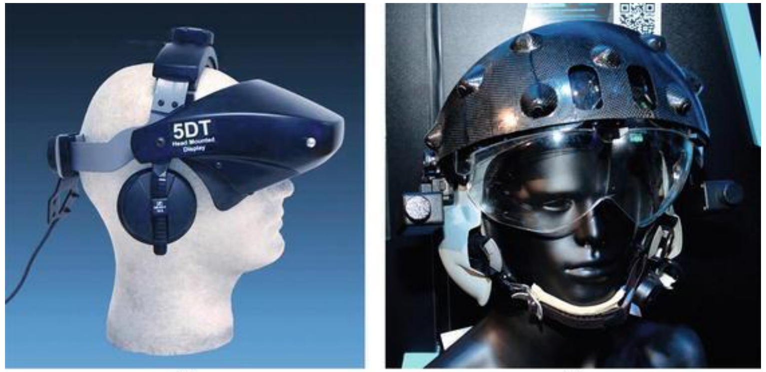


Stationary display

Stationary display –
Desktop display & CAVE

Head Based displays (HBD)





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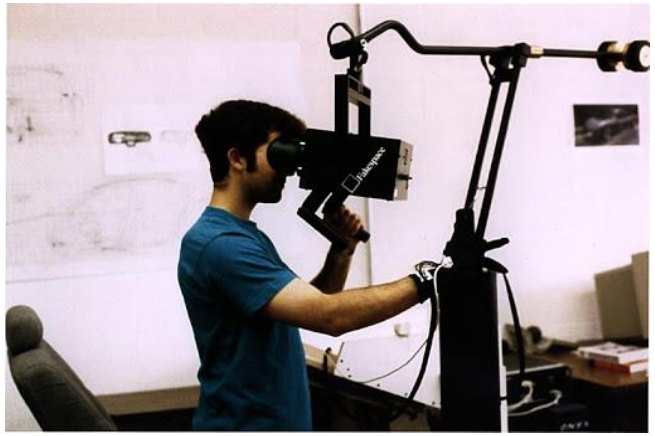
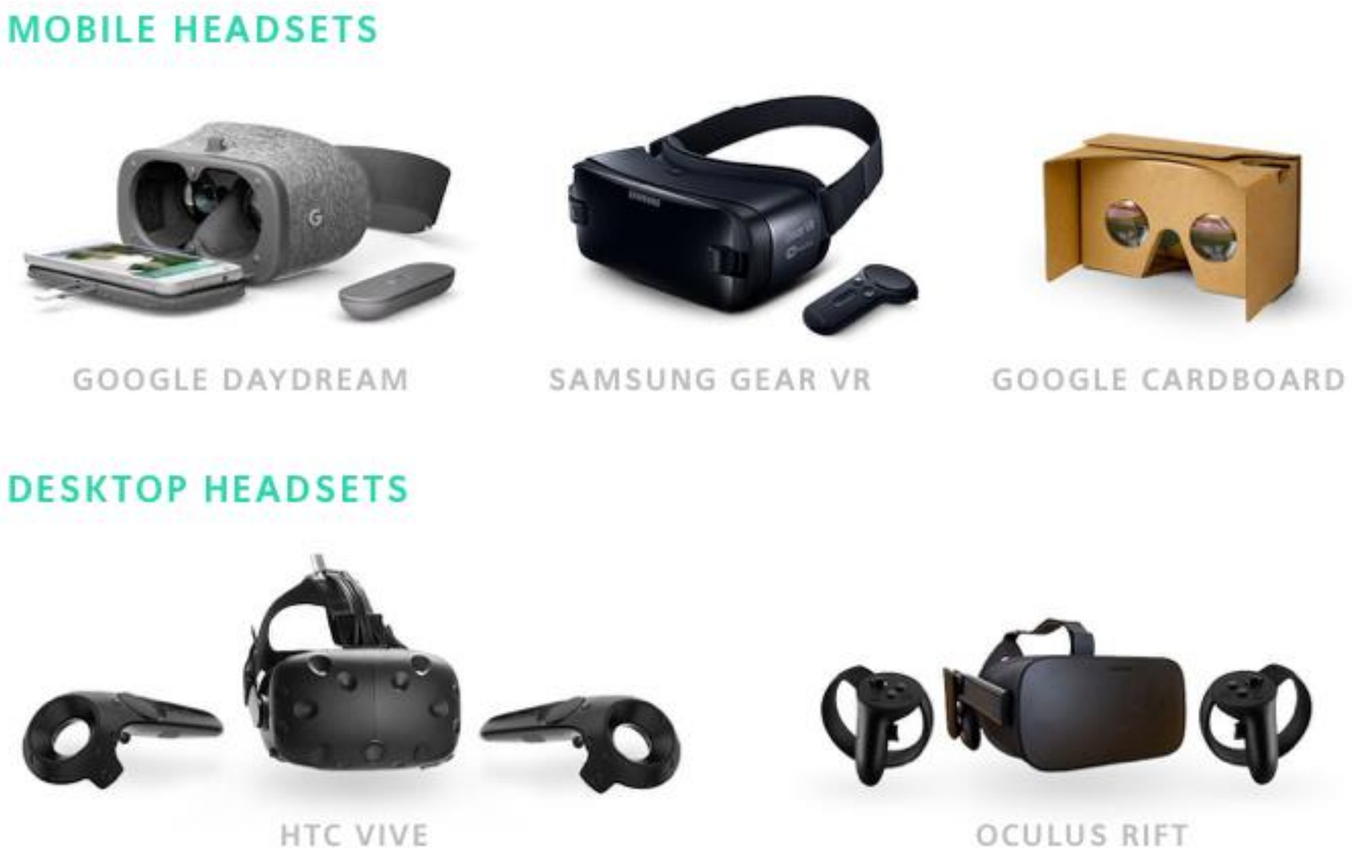


HMD


MOBILE HEADSETS
GOOGLE DAYDREAM
SAMSUNG GEAR VR
GOOGLE CARDBOARD
DESKTOP HEADSETS
HTC VIVE
OCULUS RIFT

Hand based VR display

- Pair of binoculars
- Palm size devices

Aural Display

- Loudspeaker
- Headphone

Video to experience aural display

- https://www.youtube.com/watch?v=__-AS_2KKtc

Haptics

- Haptics , is the technology of adding the sensation of touch and feeling to computers.
- When virtual objects are touched, they seem real and tangible.
- Derived from greek word haptikos‟ meaning “ABLE TO COME INTO CONTACT WITH”

 Haptics = Touch = Connection

 Touch is at the core of personal experience.

 Of the five senses, touch is the most proficient, the only one capable of simultaneous input and output Haptic senses links to the brain's sensing position and movement of the body by means of sensory nerves within the muscles and joints.

Haptic Display

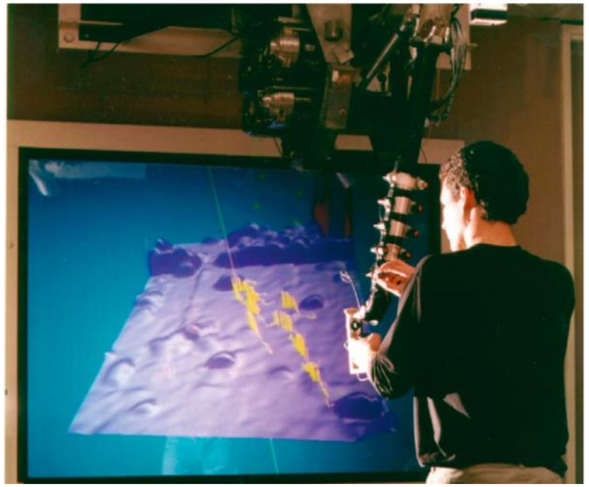
Components:

- Tactile – Input through skin
- Proprioceptic – Input through the muscular and skeletal systems

Display:

i. World grounded display

ii. Self grounded display



Haptic information

Combination Of :

Tactile Information

Refers to the information acquired by the sensors connected to the body

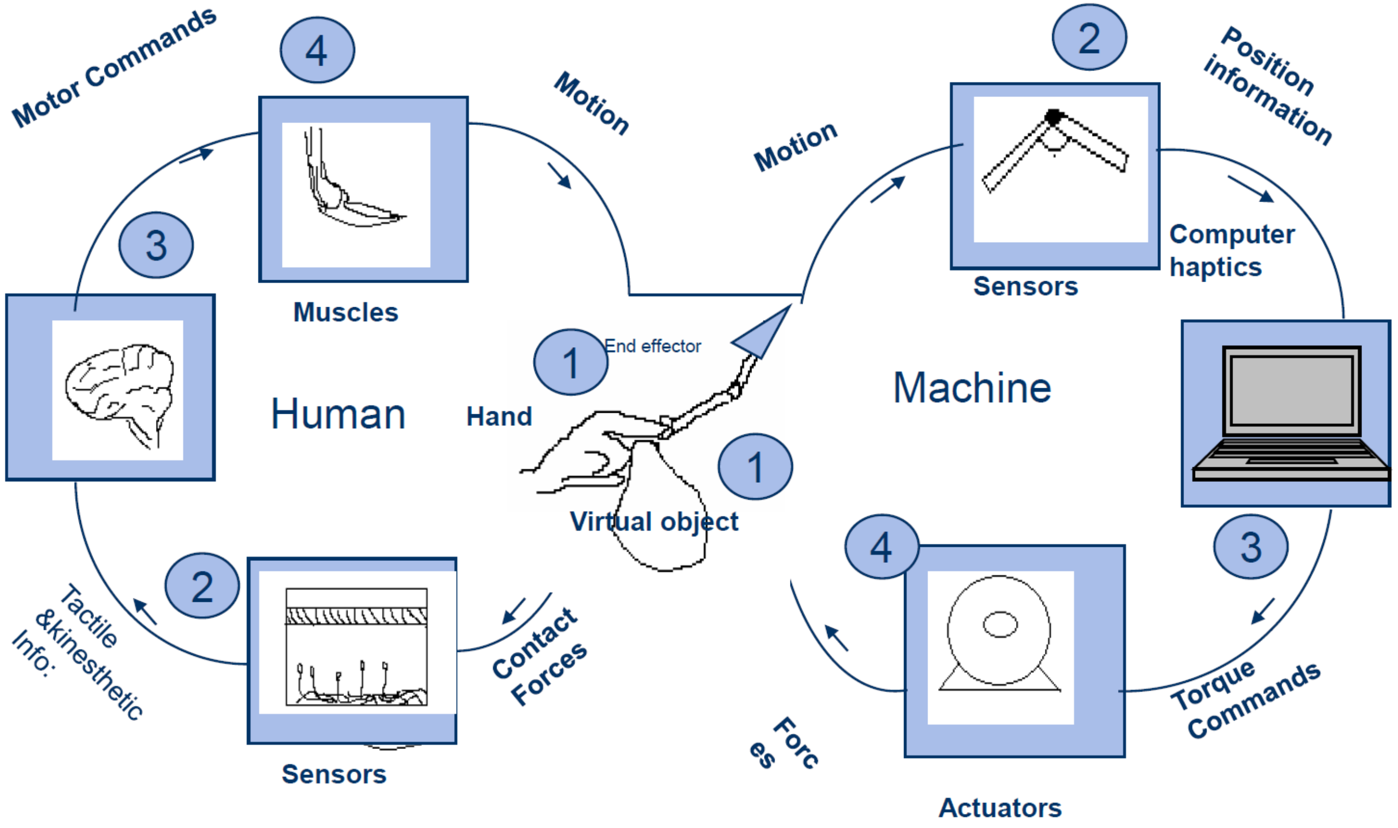
Kinesthetics Information

Refers to the information acquired by the sensors inthe joints

TYPES OF HAPTIC DEVICES

1) **VIRTUAL REALITY/ TELEROBOTICS BASED DEVICES**
   - EXOSKELETONS AND STATIONARY DEVICES
   - GLOVES AND WEARABLE DEVICES
   - POINT SOURCES AND SPECIFIC TASK DEVICES
   - LOCOMOTION INTERFACES
2) **FEEDBACK DEVICES**
   - FORCE FEEDBACK DEVICES
   - TACTILE DISPLAY DEVICES

Basic Configuration



Haptic Feedback

- Greatly improves realism
- Hands and wrist are most important
  - High density of touch receptors
- Two kinds of feedback:
  - Touch Feedback
    - information on texture, temperature, etc.
    - Does not resist user contact
  - Force Feedback
    - information on weight, and inertia.
    - Actively resists contact motion

Commonly used Haptic device - Phantom

- providing a 3D touch to the virtual objects
- provides 6 d.o.f
- when the user move his finger, then he could really feel the shape and size of the virtual 3D object that has been already programmed
- virtual 3 dimensional space in which the phantom operates is called haptic scene

Commonly used Hepatic device – Cyber Grasp

- The CyberGrasp system fits over the user's entire hand like an exoskeleton and adds resistive force feedback to each finger
- Allows 4 dof for each finger
- Adapted to different size of the fingers
- Located on the back of the hand
- Measure finger angular flexion (The measure of the joint angles are independent and can have a good resolution given the important paths traveled by the cables when the finger shut

Haptic Rendering

❑PRINCIPLE OF HAPTIC INTERFACE

❖Interaction occurs at an interaction tool that mechanically couples two controlled dynamical systems :

a) haptic interface with a computer

b) human user with a central nervous system

❑CHARACTERISTICS

❖Low back-drive inertia and friction

❖Balanced range,resolution and bandwidth of position sensing and force reflection, minimal constraints on motion

❖Symmetric inertia,friction,stiffness and resonant frequency properties, proper ergonomics

Video – Haptic

https://www.youtube.com/watch?v=XnDoej4mnHU

Other Sensory display

- Vestibular display (Sense of balance) - Motion platform & Bladder equipped chair.
- Olfactory display (smell)
- Computer controlled display of gustation (Taste)

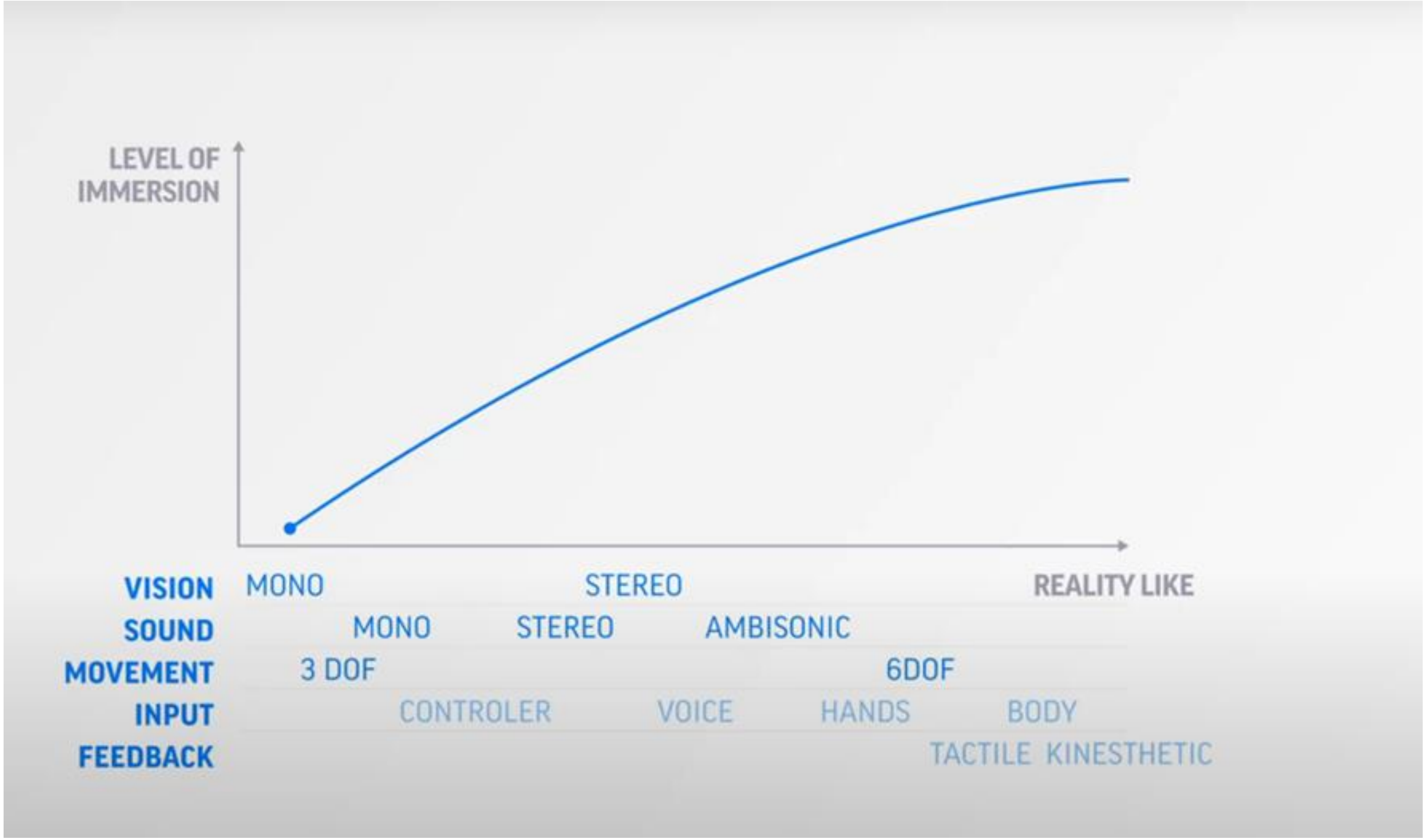
Degrees of Freedom

- Degree of Freedom = independent movement about an axis
  - 3 DoF Orientation = roll, pitch, yaw (rotation about x, y, or z axis)
  - 3 DoF Translation = movement along x,y,z axis
- Different requirements
  - User turns their head in VR -> needs 3 DoF orientation tracker
  - Moving in VR -> needs a 6 DoF tracker (r,p,y) and (x, y, z)

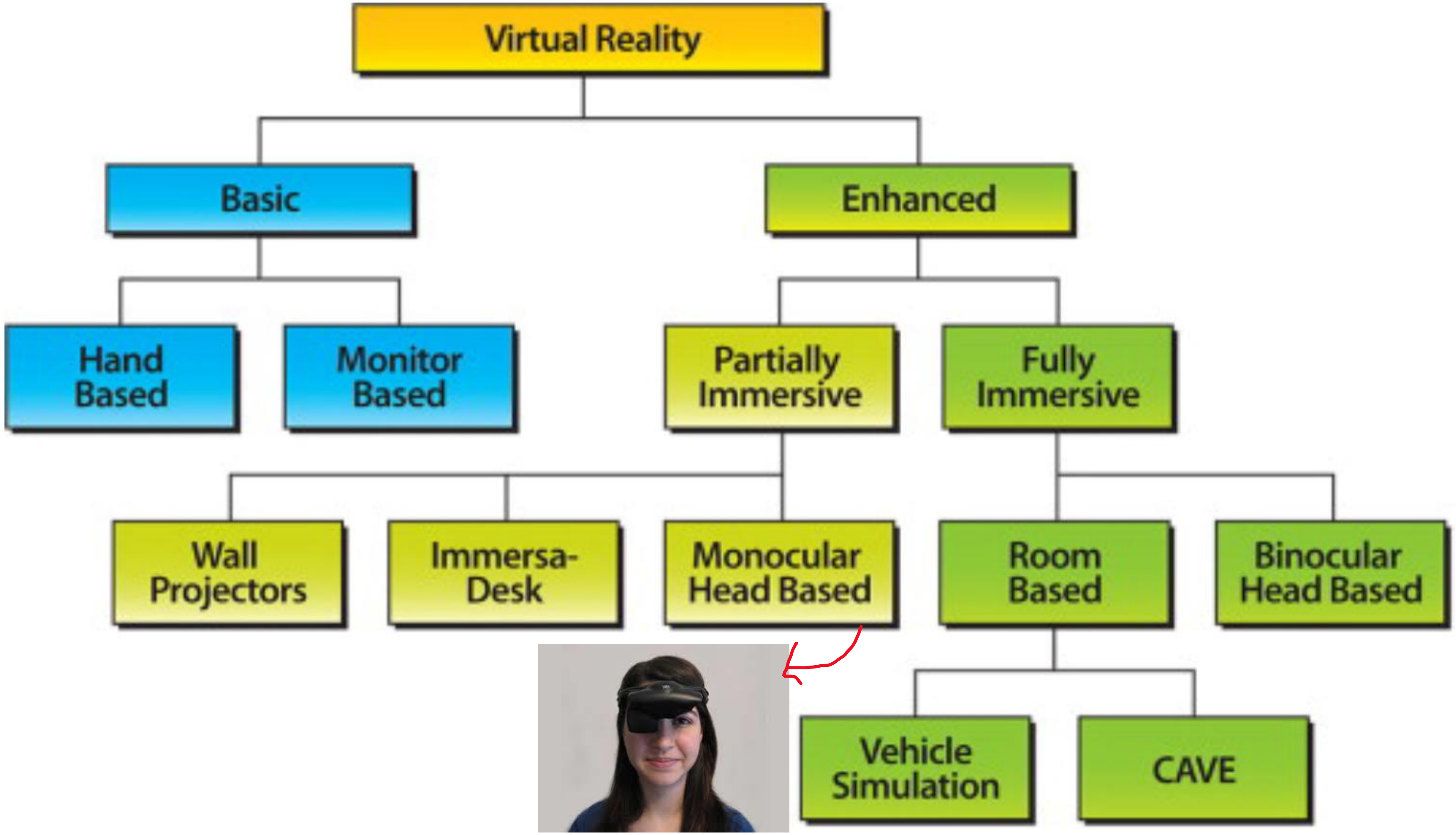
Videos - DoF

- https://www.youtube.com/watch?v=Hfzkfi_RMeI

- https://www.youtube.com/watch?v=DdvBrKl3SHg


LEVEL OF IMMERSION
VISION
MONO
STEREO
REALITY LIKE
SOUND
MONO
STEREO
AMBISONIC
MOVEMENT
3 DOF
6DOF
INPUT
CONTROLER
VOICE
HANDS
BODY
FEEDBACK
TACTILE
KINESTHETIC

VR Display Taxonomy



Input Devices & User Tracking

Input Devices

VR Input Devices

Hand Input Devices

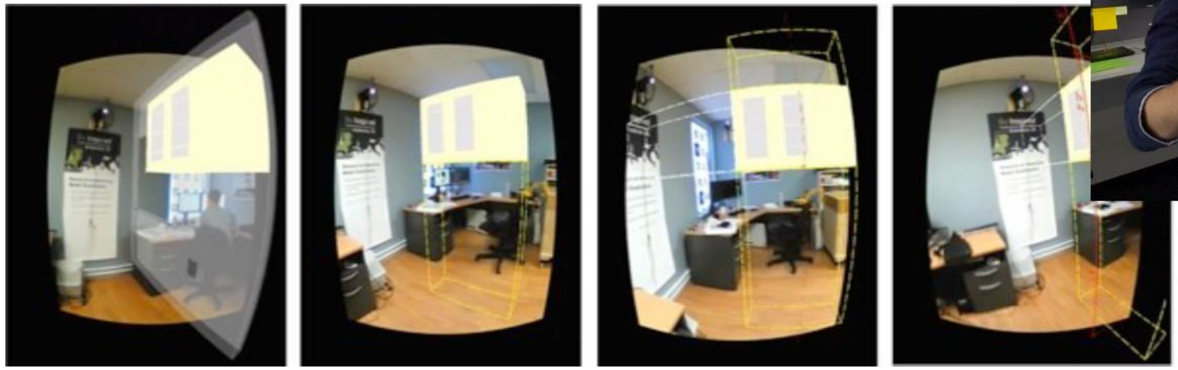
- Devices that integrate hand input into VR
- World-Grounded input devices
  - Devices fixed in real world (e.g. joystick)
- Non-Tracked handheld controllers
  - Devices held in hand, but not tracked in 3D (e.g. xbox controller)
- Tracked handheld controllers
  - Physical device with 6 DOF tracking inside (e.g. Vive controllers)
- Hand-Worn Devices
  - Gloves, EMG bands, rings, or devices worn on hand/arm
- Bare Hand Input
  - Using technology to recognize natural hand input

VR Input Devices

Non-Hand Input Devices

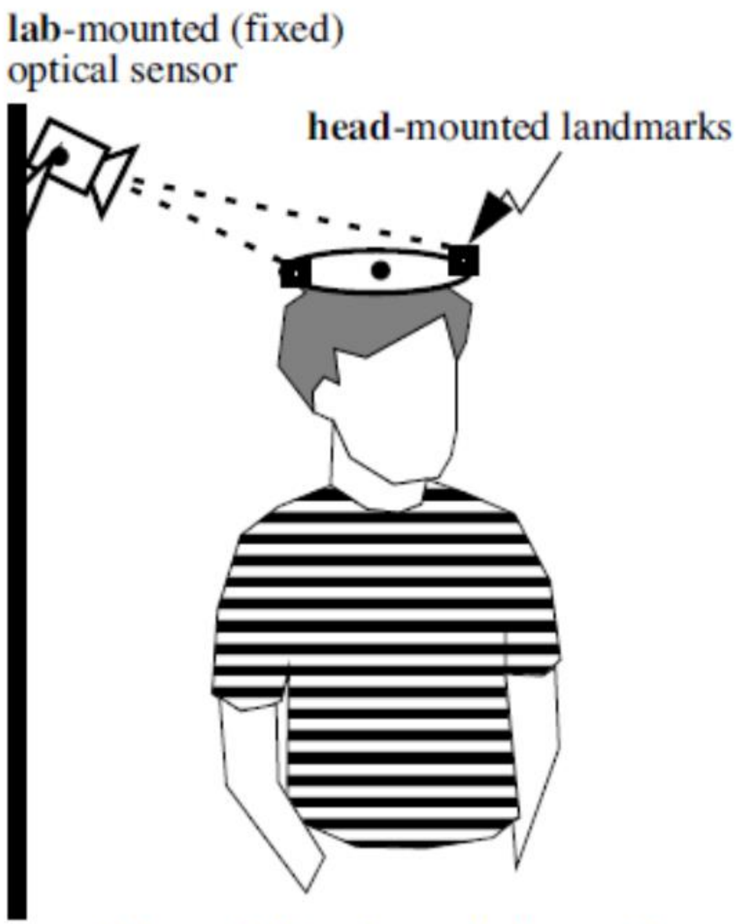
- Capturing input from other parts of the body
- Head Tracking
  - Use head motion for input
- Eye Tracking
  - Largely unexplored for VR
- Microphones
  - Audio input, speech
- Full-Body tracking
  - Motion capture, body movement

Tracking in VR

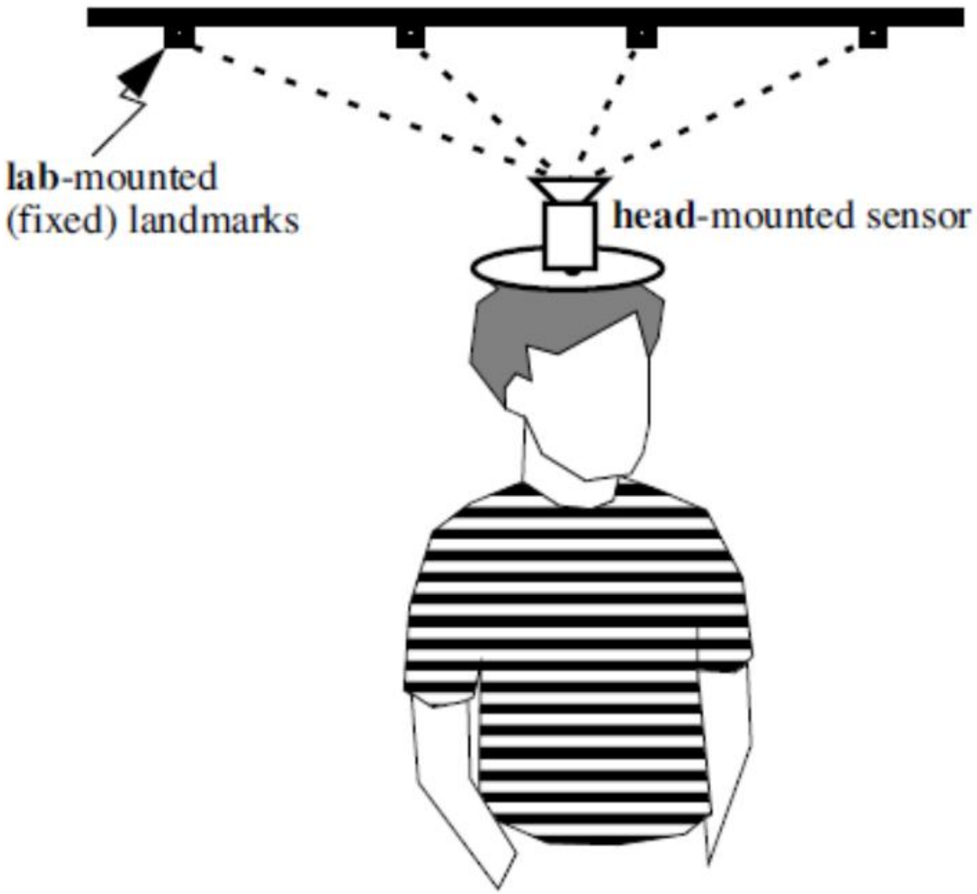


- Need for Tracking
  - User turns their head and the VR graphics scene changes
  - User wants to walking through a virtual scene
  - User reaches out and grab a virtual object
  - The user wants to use a real prop in VR
- All of these require technology to track the user or object
  - Continuously provide information about position and orientation

Outside-In vs. Inside-Out Tracking



Outside-Looking-In

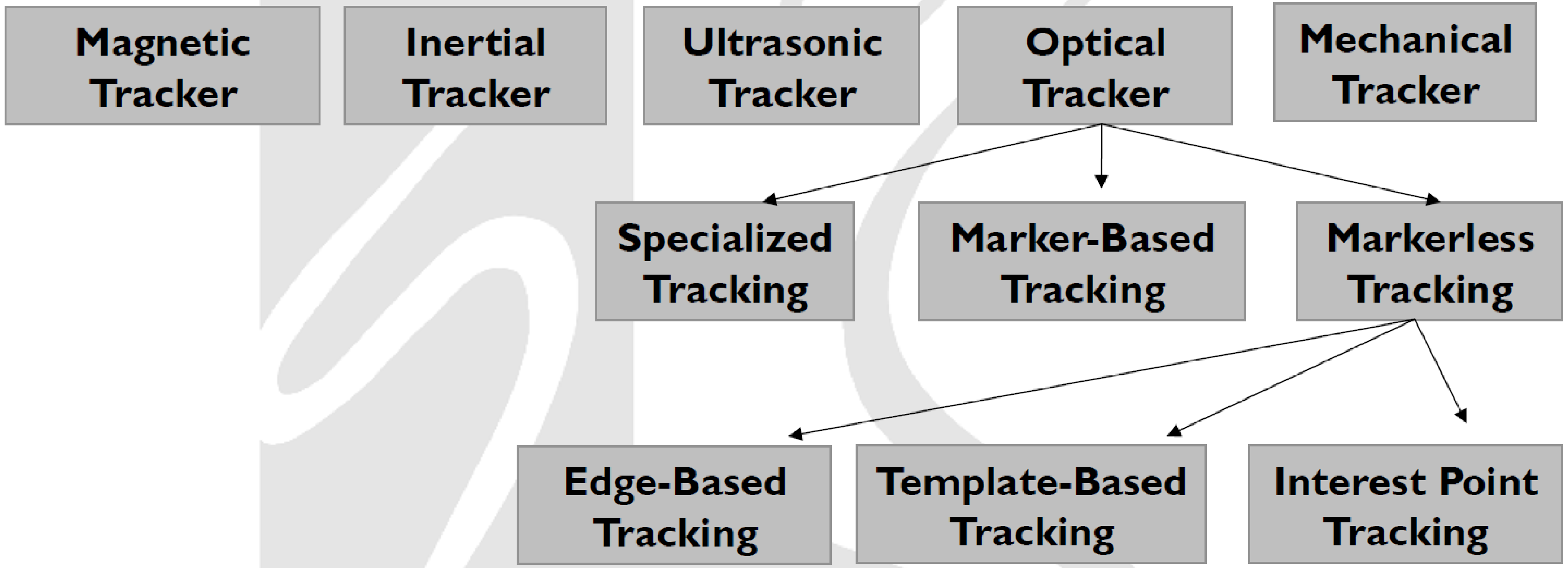


Inside-Looking-Out

https://www.youtube.com/watch?v=IWYsdHZDNJk&t=60s

https://www.youtube.com/watch?v=2jY3B_F3GZk

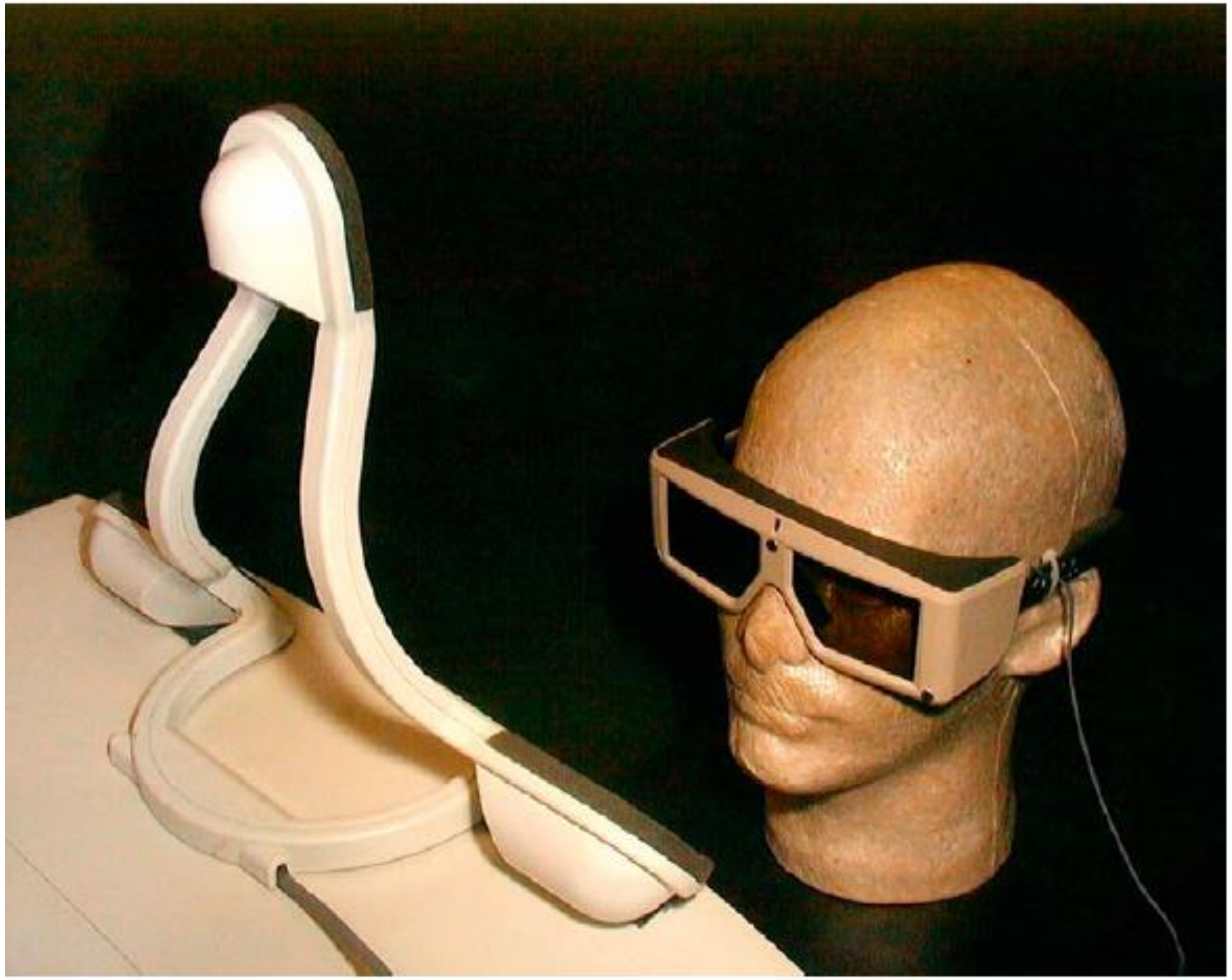
Tracking Types



Electomagnetic Tracking system

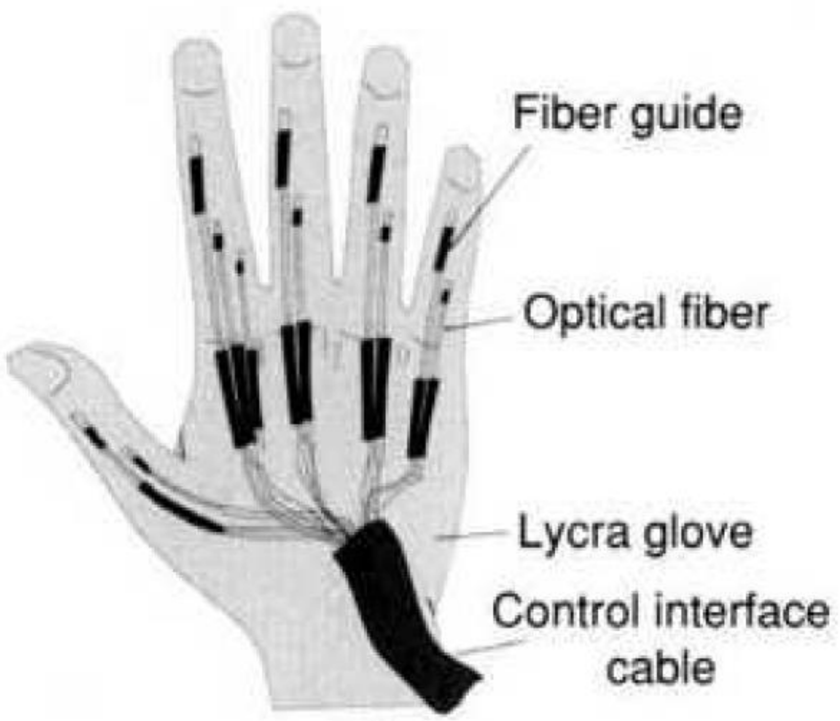
A low-level electromagnetic field is emitted by the large black box. The signal is sensed by a receiving antenna, which allows the system to determine the location and orientation of the receiver.

Ultrasonic Tracking system

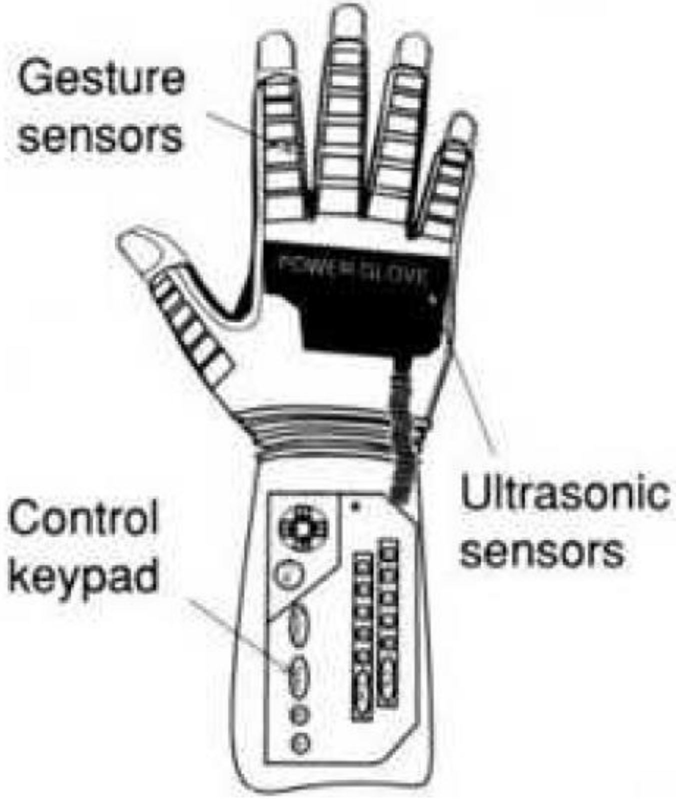


This basic ultrasonic tracking system uses three speakers and three microphones triangularly arranged to measure the distance between all the speaker-microphone pairs from which the location/orientation of the glasses can be determined.

Mechanical Tracker



Data glove

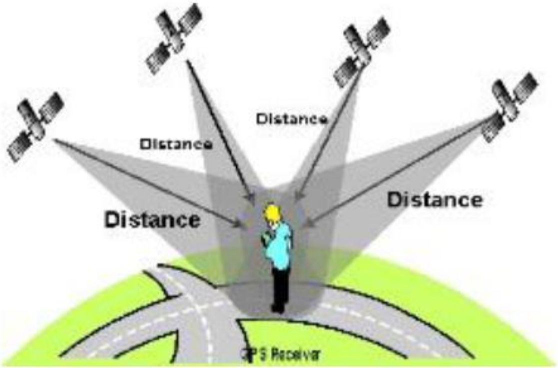


Power glove

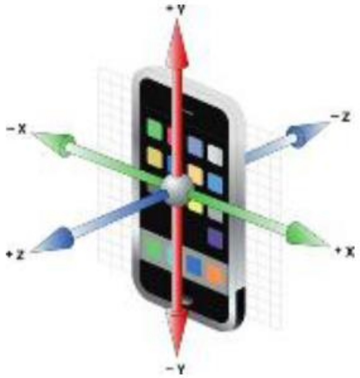
Optical Tracker

Tracking Technologies

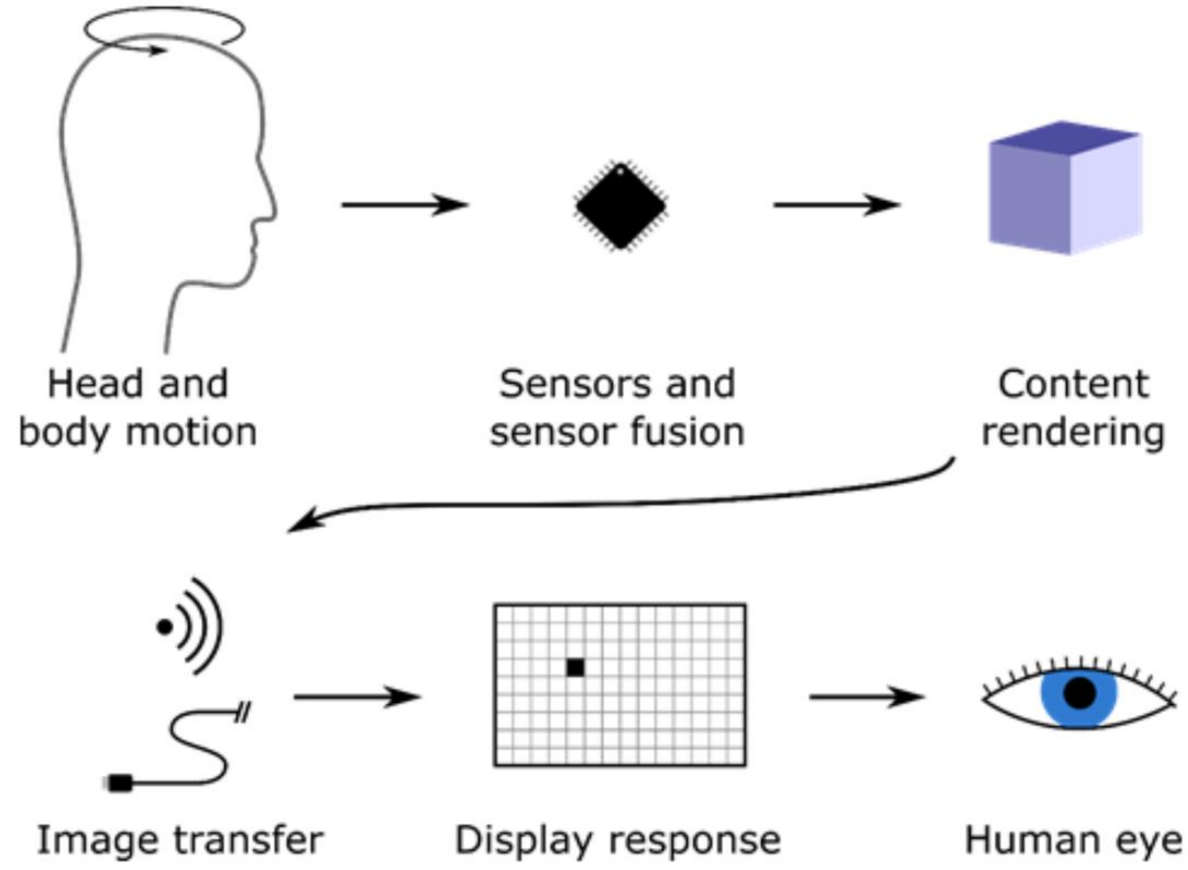
- Active (device sends out signal)
  - Mechanical, Magnetic, Ultrasonic
  - GPS, Wifi, cell location



- Passive (device senses world)
  - Inertial sensors (compass, accelerometer, gyro)
  - Computer Vision
    - Marker based, Natural feature tracking
- Hybrid Tracking
  - Combined sensors (eg Vision + Inertial)



Tracking and Rendering in VR



Tracking fits into the graphics pipeline for VR

Coordinate

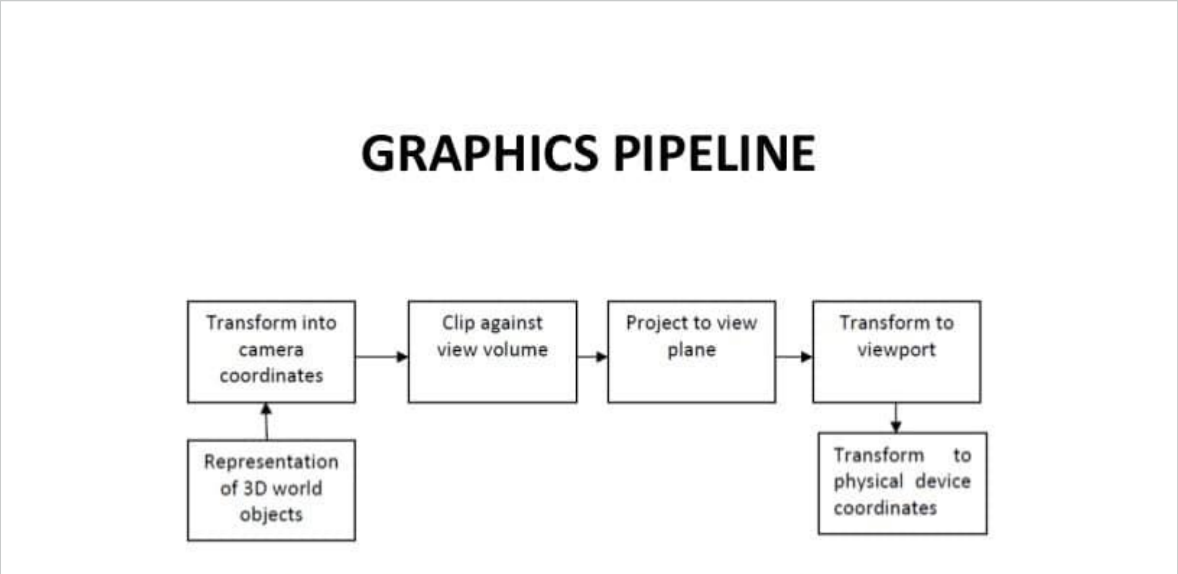
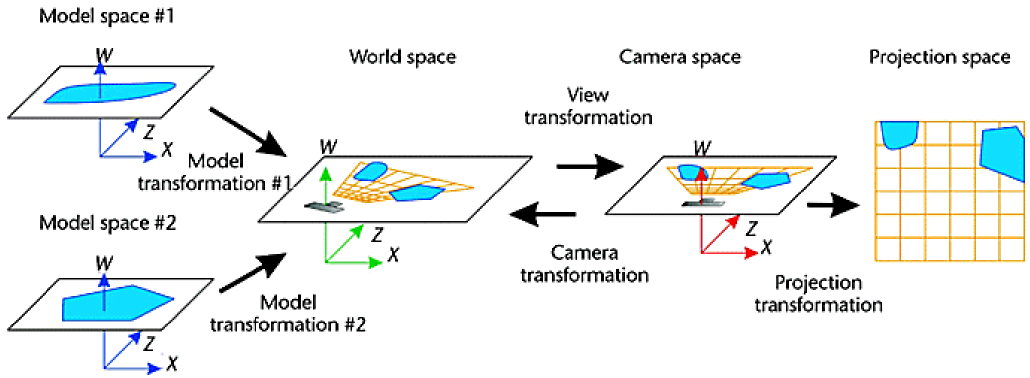
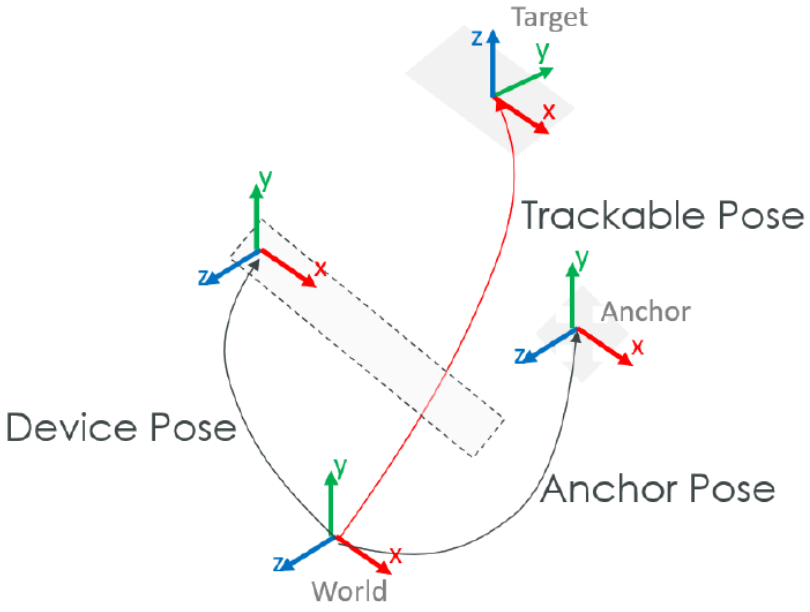
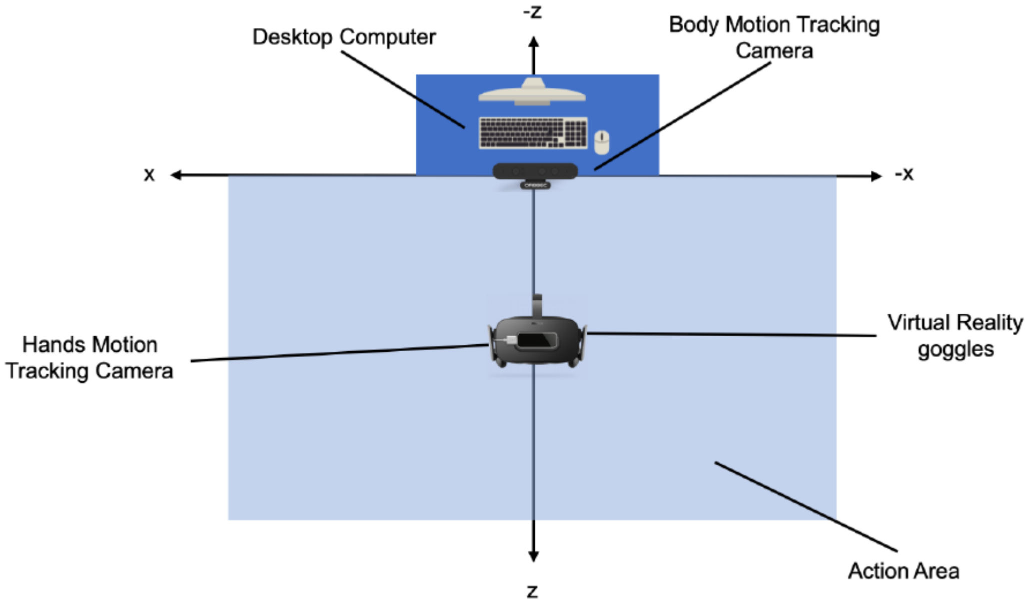


Figure : Sequence of transformation in viewing pipeline

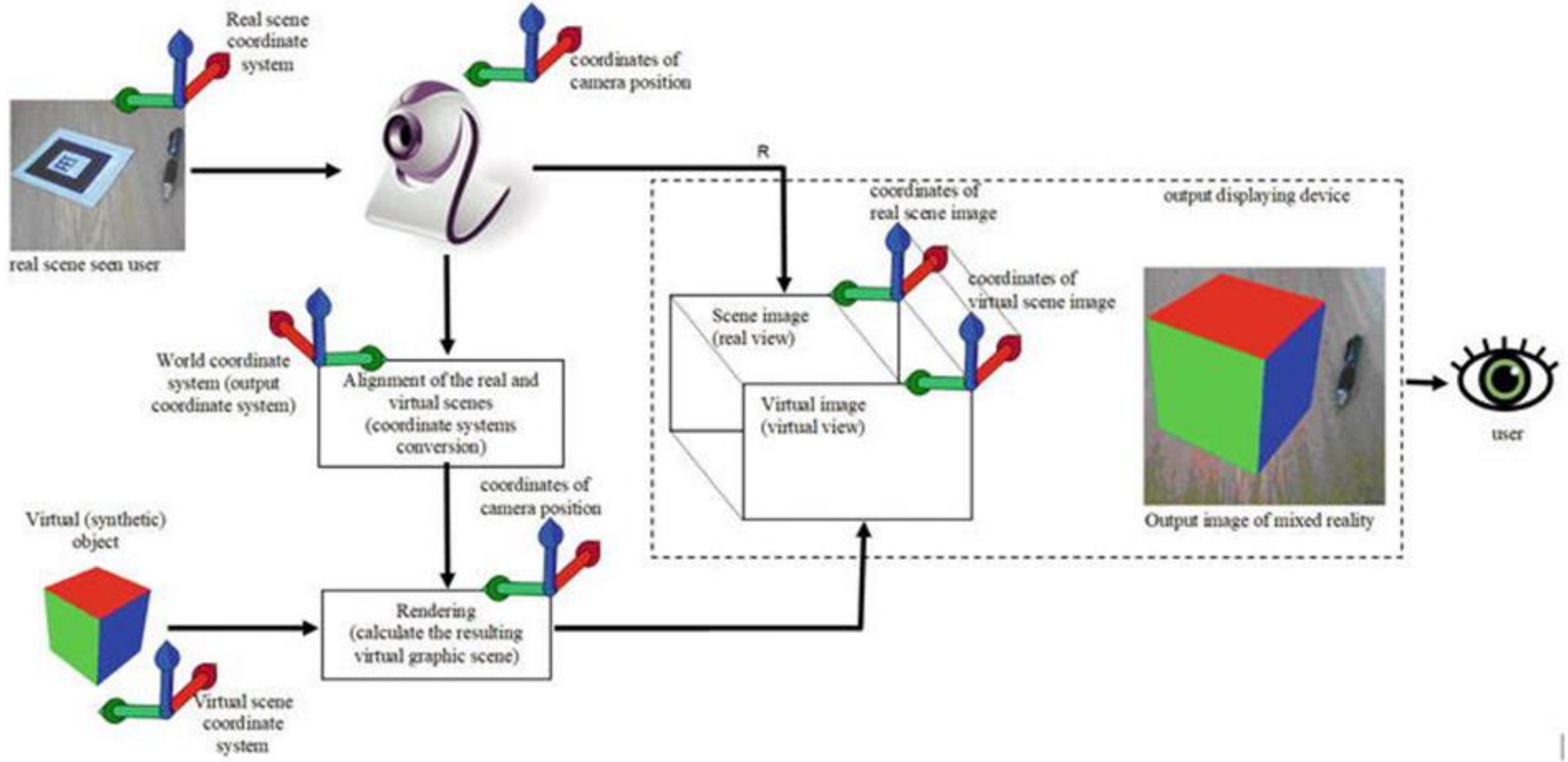


Tracking Coordinate Frames

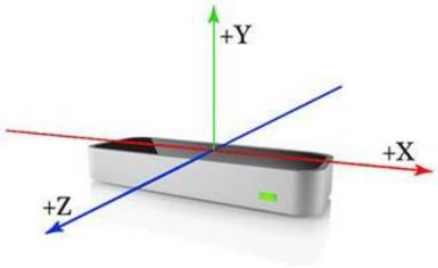


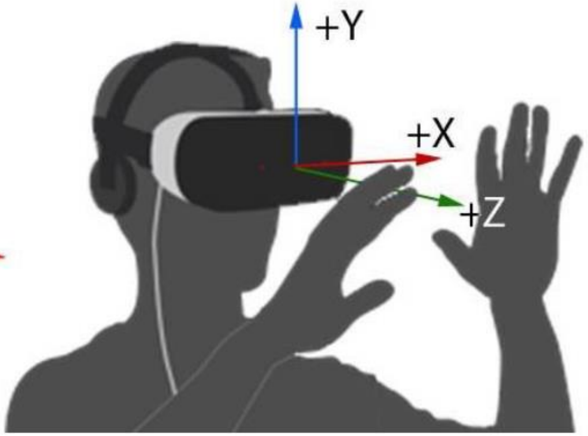


- There can be several coordinate frames to consider
  - Head pose with respect to real world
  - Coordinate fame of tracking system wrt HMD
  - Position of hand in coordinate frame of hand tracker


Real scene
coordinate
system
coordinates of
camera position
real scene seen user
R
output displaying device
coordinates of
real scene image
coordinates of
virtual scene image
Scene image
(real view)
Virtual image
(virtual view)
World coordinate
system (output
coordinate system)
Alignment of the real and
virtual scenes
(coordinate systems
conversion)
user
Output image of mixed reality
coordinates of
camera position
Virtual (synthetic)
object
Rendering
(calculate the resulting
virtual graphic scene)
Virtual scene
coordinate
system

Example: Finding your hand in VR





- Using Lighthouse and LeapMotion
- Multiple Coordinate Frames
  - LeapMotion tracks hand in LeapMotion coordinate frame (H_{LM})
  - LeapMotion is fixed in HMD coordinate frame (LM_{HMD})
  - HMD is tracked in VR coordinate frame (HMD_{VR}) (using Lighthouse)
- Where is your hand in VR coordinate frame?
  - Combine transformations in each coordinate frame
  - $H_{VR} = H_{LM} \times LM_{HMD} \times HMD_{VR}$

Video : Tracking

https://www.youtube.com/watch?v=_q_8d0E3tDk&t=3s

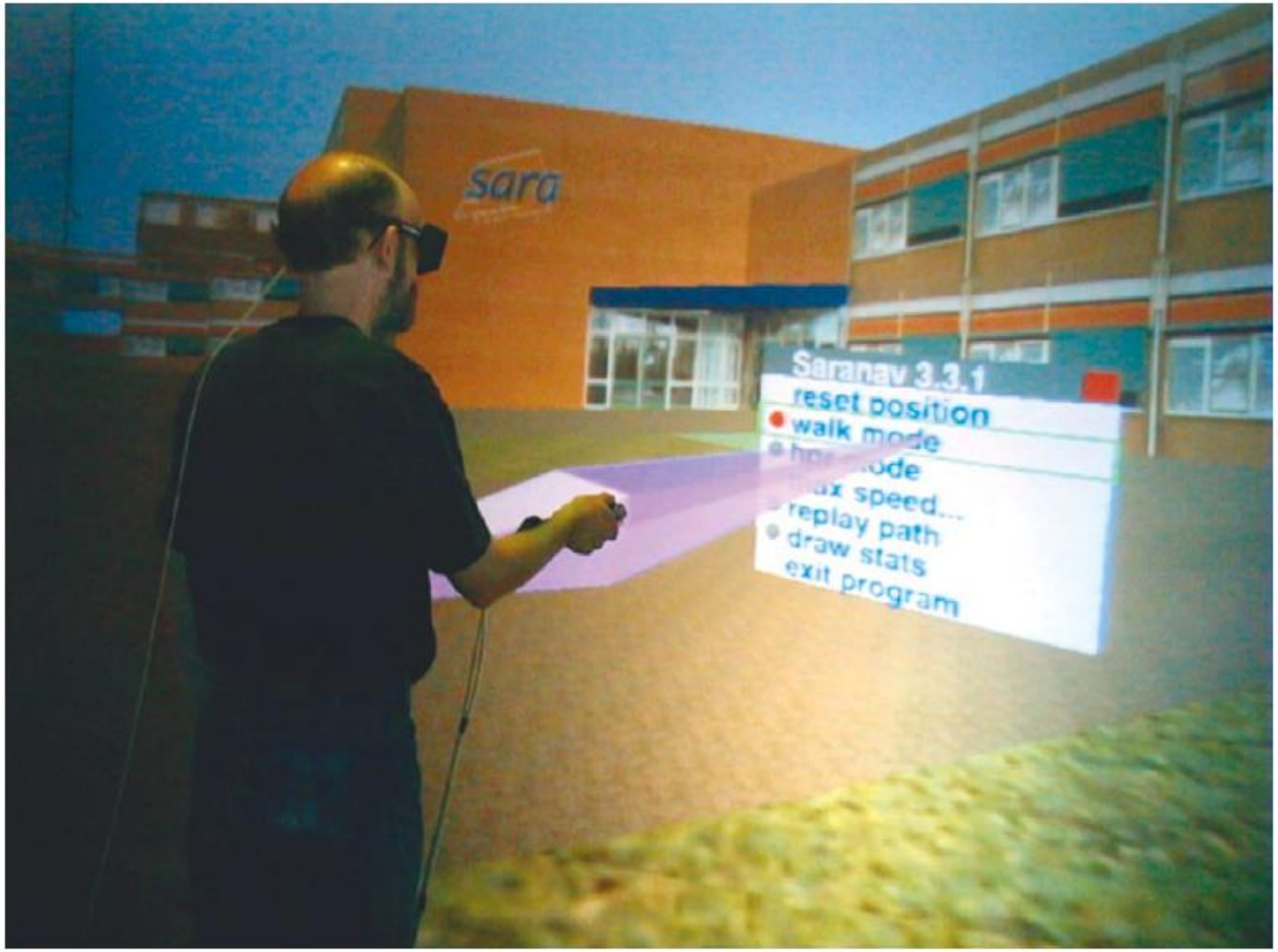
Video : Full body tracking

https://www.youtube.com/watch?v=X5POJ1NdRXg

Video : Cyberith demo

https://www.youtube.com/watch?v=q_rv-213IjI

3D Menus



The menu is an interface technique that has been adapted to the virtual reality medium from the realm of desktop computer interfaces.

Video – 3D Menu

https://www.youtube.com/watch?v=ZAaW00gcD78

Interaction Techniques

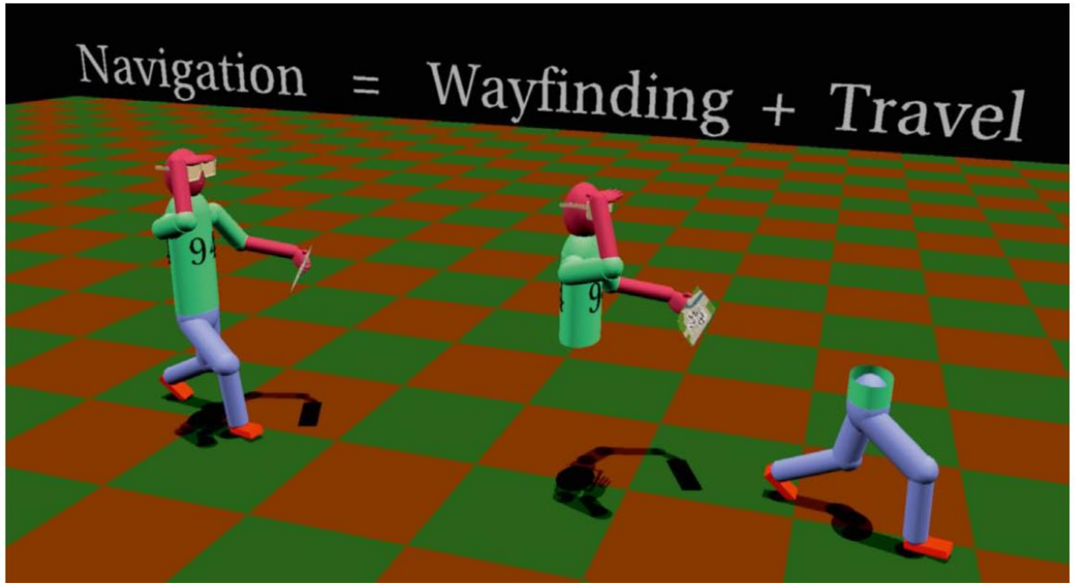
- Direct
- Physical
- Virtual
- Agent

Steering a vehicle is one way in which the participant can use a physical device to interface with the virtual world.

Interacting with a graphical (virtual) controller is an example of a virtual input interaction, such as moving this table using a virtual slider.

Interaction Steps

1. Make Selection
2. Perform manipulation
3. Navigation



The task of navigating through a world can be broken into the component tasks of wayfinding (figuring out where you are and where to go) and travel (moving through the world).

Travel Paradigms used in VR experiences

- *Physical locomotion* is the simplest method of travel in VR. It is merely the ability for participants to move their bodies to change the position of their point of view within the virtual world. Physical locomotion travel is generally available in VR experiences, often in combination with another form of travel.
- *Ride-along* describes the method of travel that gives participants little or no freedom. They are taken along a predetermined path through the virtual world, perhaps with occasional choice-points. Usually participants can change their point of view or "look around" while on that path.
- *Tow-rope* travel is an extension of the ride-along paradigm. In this case, the user is being pulled along a predetermined path, but with the ability to move off the centerline of the path for a small distance.
- *Fly-through* travel is a generic term for methods that give the user almost complete freedom of control, in any direction. A subset of the fly-through method is the *walk-through*. In a walk-through interface, participants' movements are constrained to follow the terrain such that they are a natural "standing" height above it.

Paradigms (Contd...)

- *Pilot-through* describes the form of travel in which users controls their movements by using controls that mimic some form of vehicle in which they are riding.

- *Orbital-viewing* is the least natural form of travel. In this method, the world (which often consists of just a model-sized collection of objects) seems to orbit about users depending on which direction they look. When users look left, the object orbits to their left, allowing them to see the right side. Looking up causes the object to orbit above them, showing the bottom side.

- *Move-the-world* is a form of travel that is often less natural than the previous forms. Here, users "grab" the world and can bring it nearer, or move or orient it in any way by repositioning their hand.
- *Scale-the-world* travel is done by reducing the scale of the world, making a small movement, and then scaling the world back to its original size. The difference between the points about which the two scaling operations are performed causes the user to reappear at a new location when returning to the original scale of the world.
- *Put-me-here* travel is a basic method that simply takes the user to some specified position. This can be somewhat natural, like telling a cab driver your destination and arriving some time later, or this method can be totally unnatural such as selecting a destination from a menu and popping there instantaneously.

3D Scanner

Video – 3D scanner

https://www.youtube.com/watch?v=lIL3vTjw1WY

Software

- Software components - integrated to enable cogent VR experiences.
- Software ranges from low-level libraries for

  - simulating events, rendering display imagery, interfacing with I/O devices,

  - creating and altering object descriptions,

  - to completely encapsulated "turnkey" systems that allow one to begin running an immersive experience with no programming effort.

Software

- Simulation code
- Rendering libraries
- VR libraries
- Ancillary software

Reference

- Images and videos used in this presentation are referred from the Internet source
- Burdea, G. C., P. Coffet., “Virtual Reality Technology”, Second Edition, Wiley-IEEE Press, 2003/2006
- Alan Craig, William Sherman, Jeffrey Will, “Developing Virtual Reality Applications, Foundations of Effective Design”, Morgan Kaufmann, 2009.