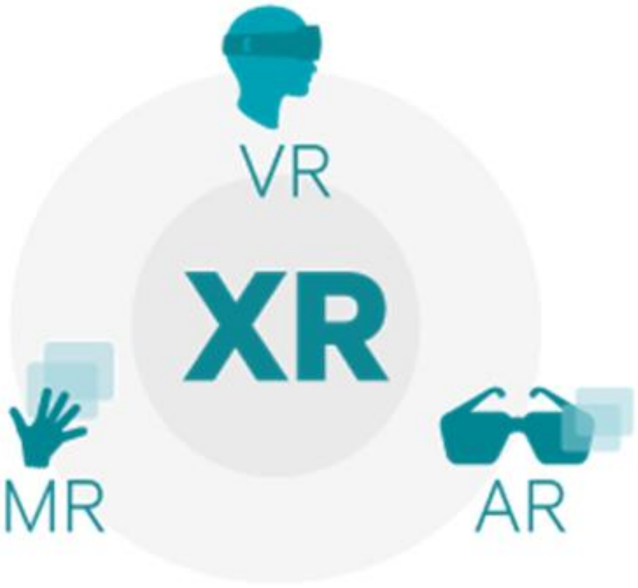


CSPE 51 – Augmented and Virtual Reality

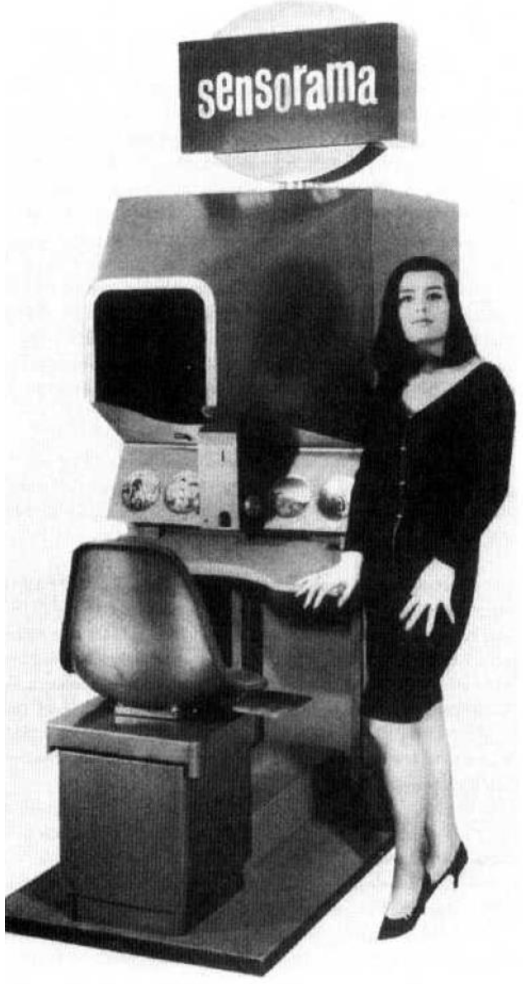
B.Tech. (CSE) – III yr – A & B Sections

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.

Primary Features and Present Development on Virtual Reality

- Virtual reality is not a new invention, but dates back more than 40 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.

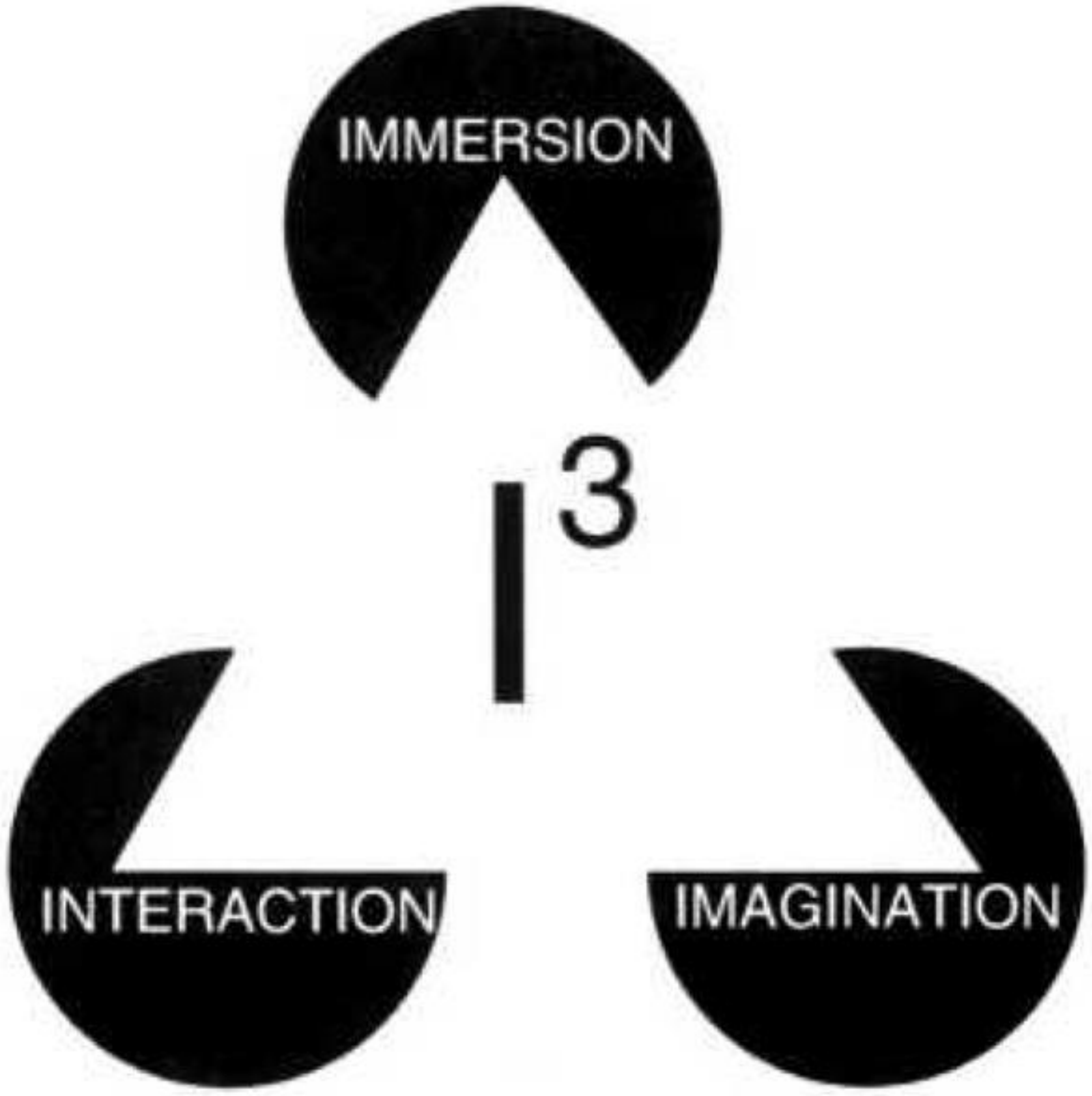
- With all the afore mentioned technological developments, scientific exchange of information among the small group of specialists of the time followed. France was one of the first countries to organize a major international conference on the subject, held in Montpellier in March 1992. The name of this 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.

Elements of VR

3 I's in VR

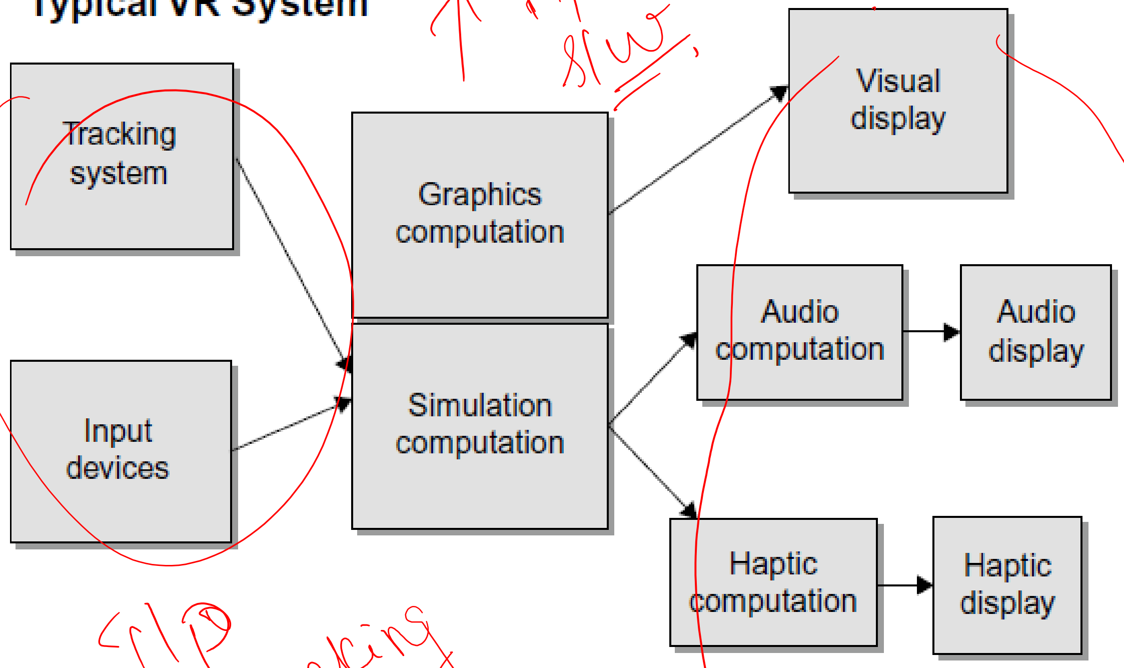


Components of Virtual Reality

Computer H/w S/w

O/p / display

Typical VR System

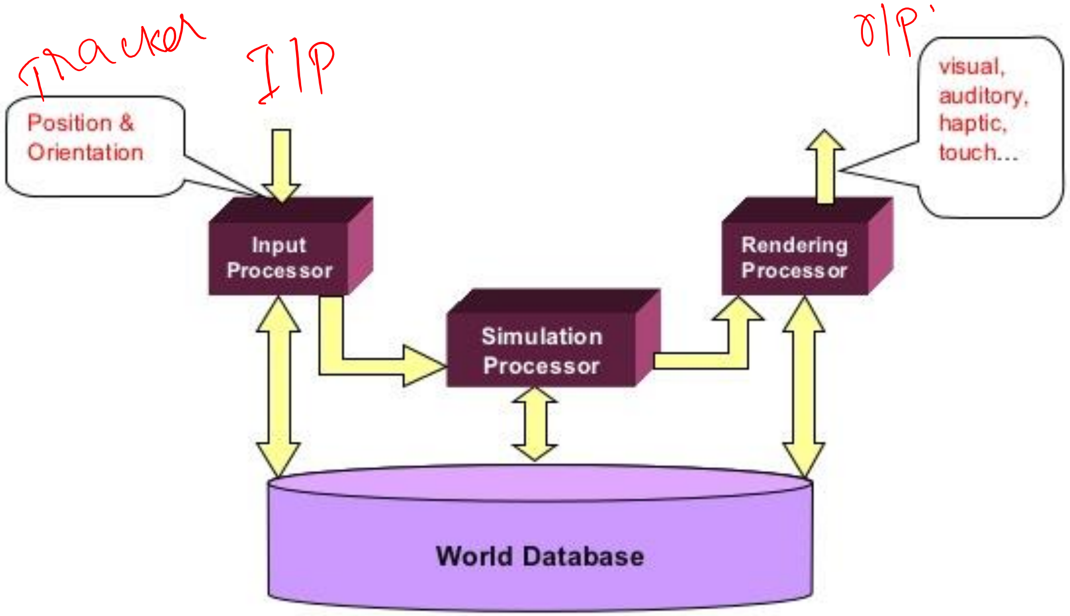


I/p & tracking

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
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  - Devices fixed in real world (e.g. joystick)
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  - Devices held in hand, but not tracked in 3D (e.g. xbox controller)
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- Eye Tracking
  - Largely unexplored for VR
- Microphones
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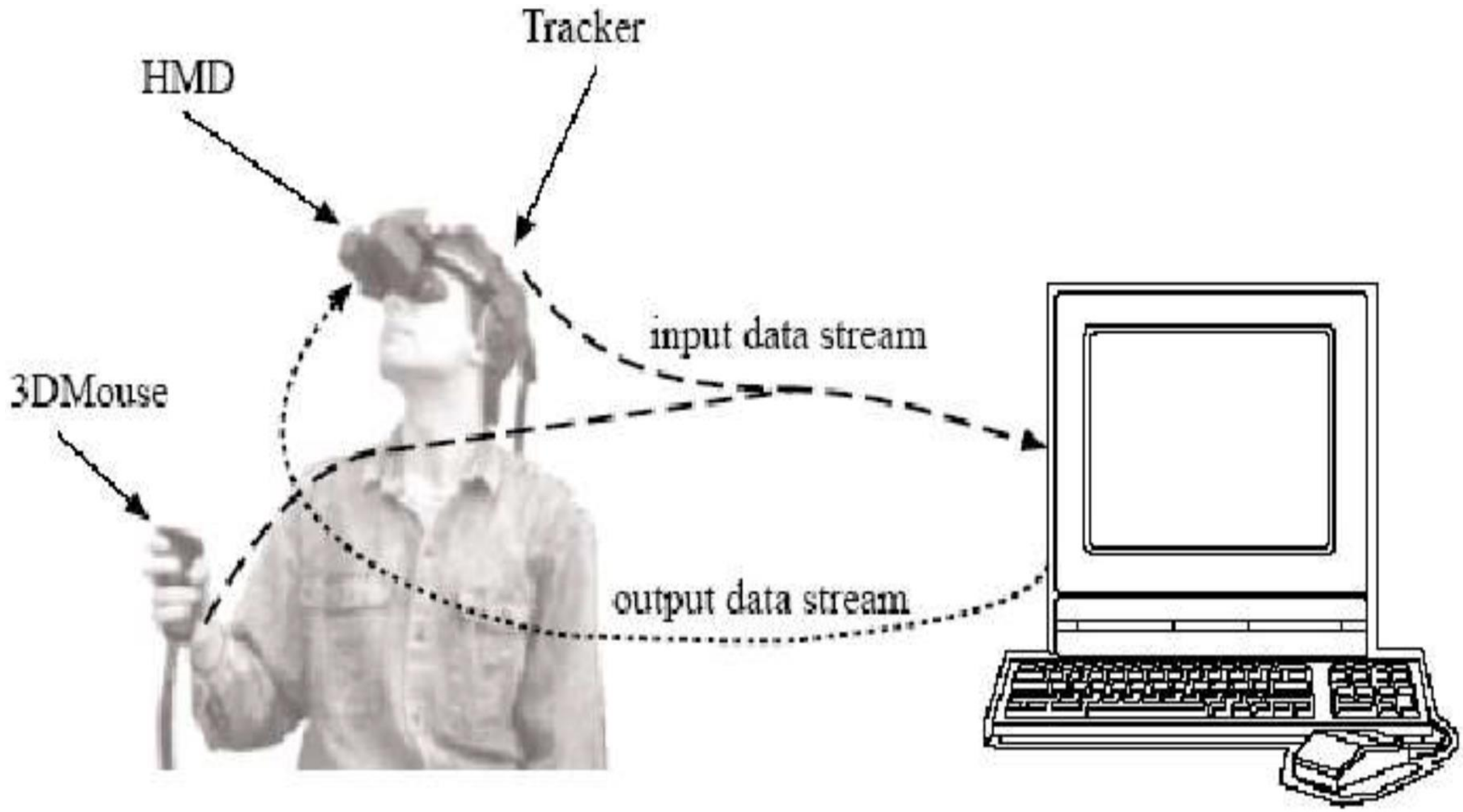
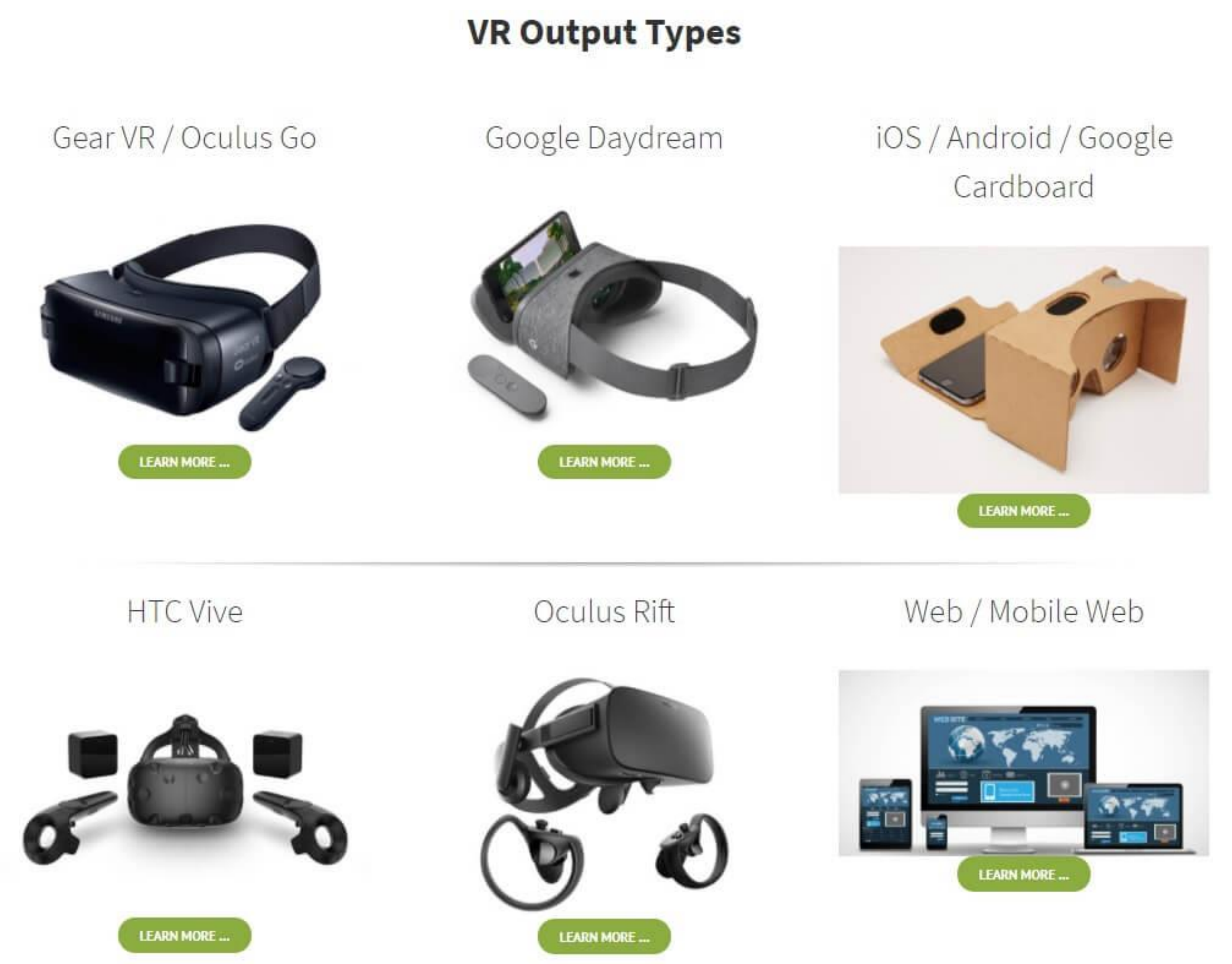
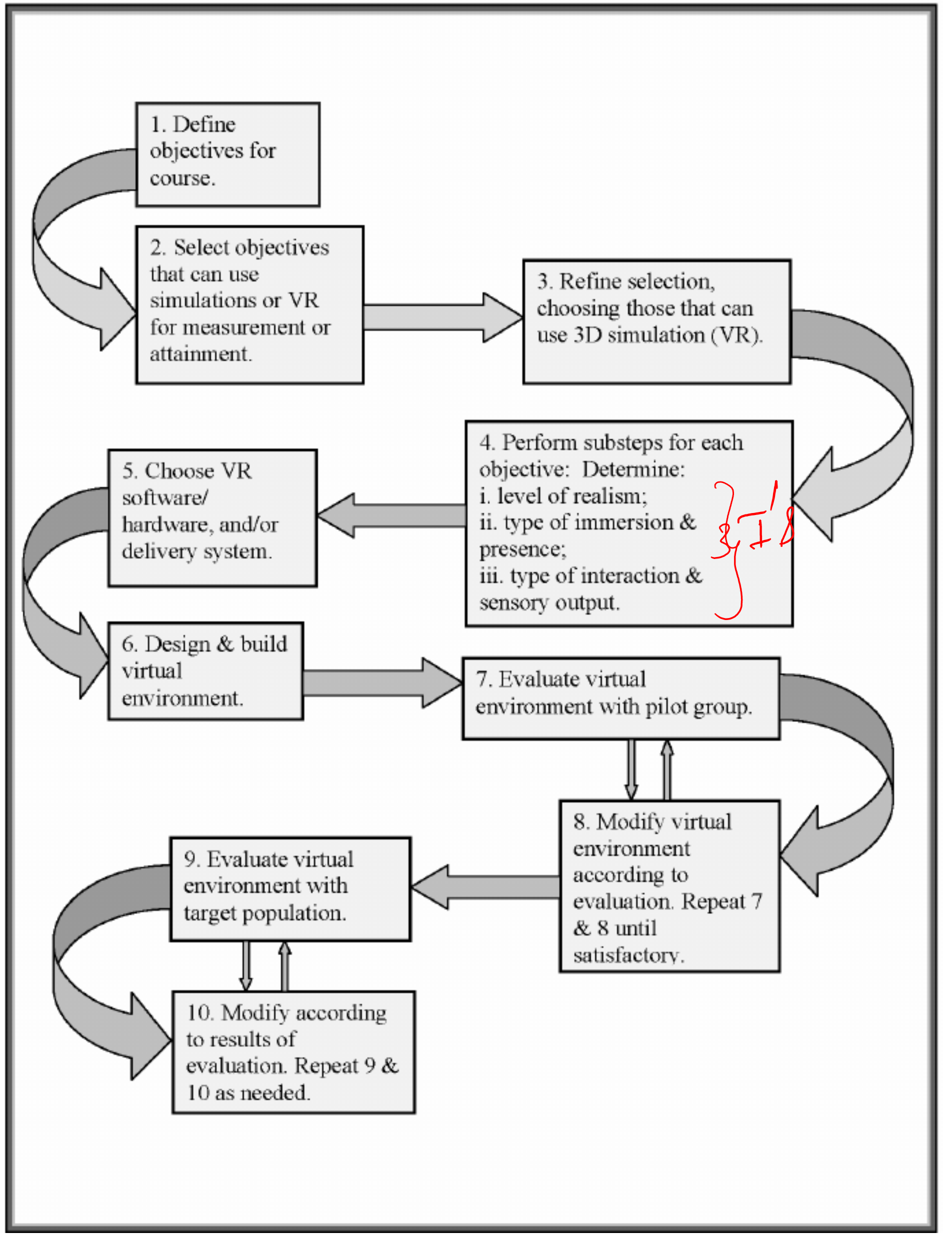
- Full-Body tracking
  - Motion capture, body movement


Tracker
HMD
input data stream
3DMouse
output data stream

VR output Devices



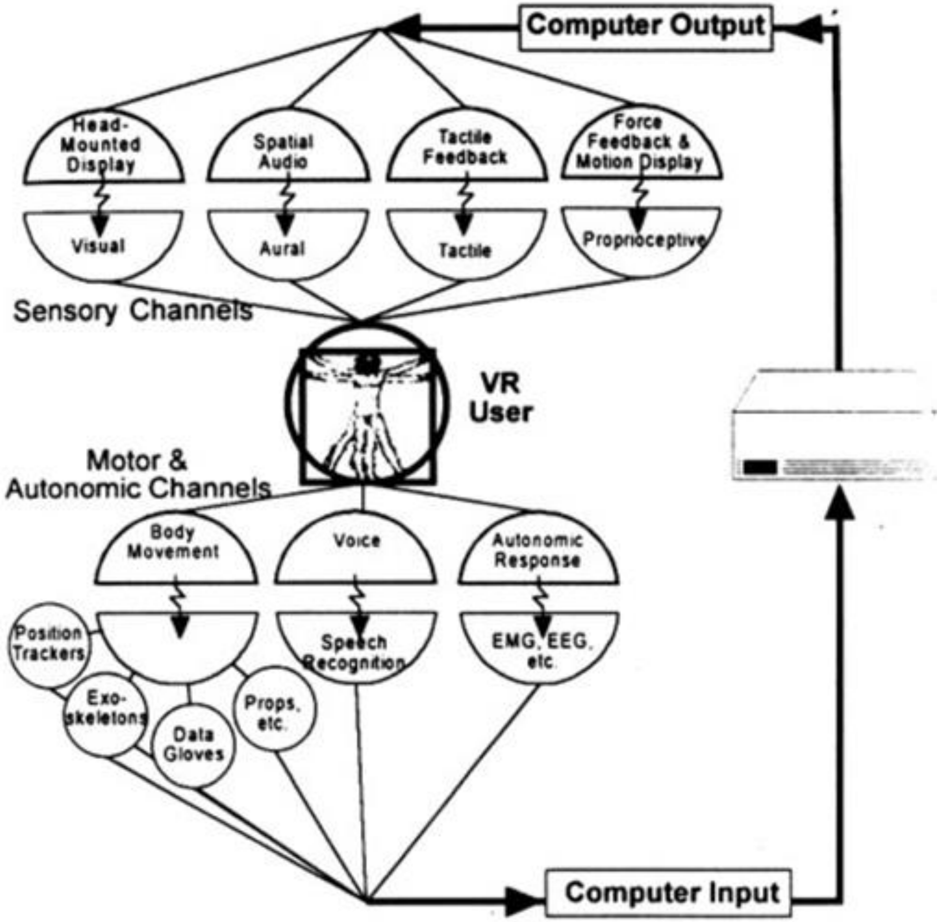
Steps involved in VR



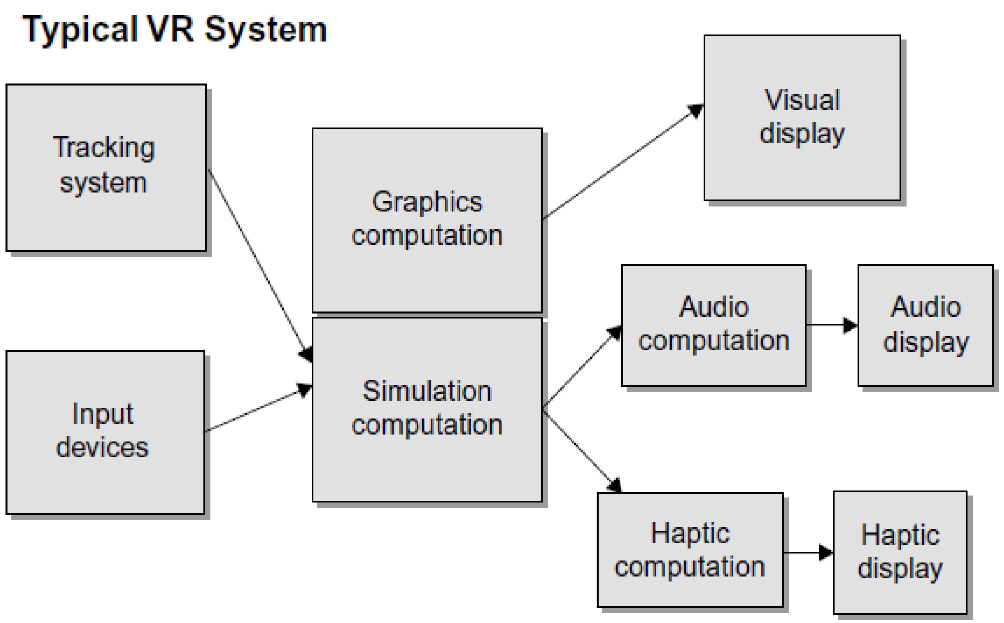
Video - Application

- 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:

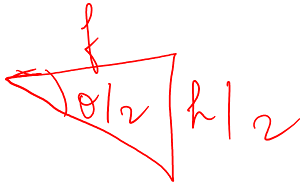
- Responsible for calculating the physical behaviour of the Virtual World
- Render the state of the world into visual, aural, haptic, …

Graphics engine:

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

OS:

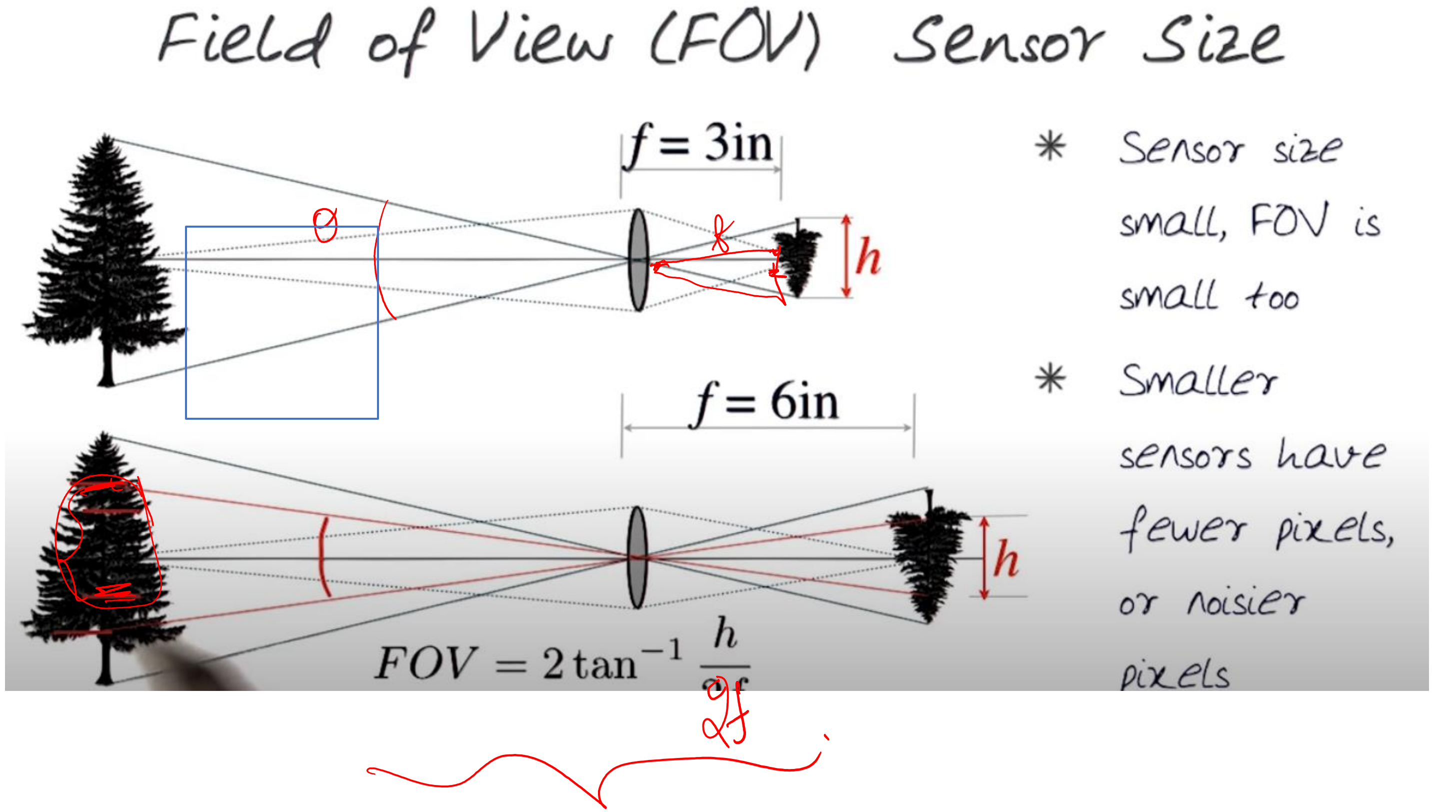
- Perform Multithreaded operations



$$\theta/2 = \tan^{-1}(h/2f)$$

$$\theta = 2\tan^{-1}(h/2f)$$

Field of View (FoV)



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

FoV & FoR

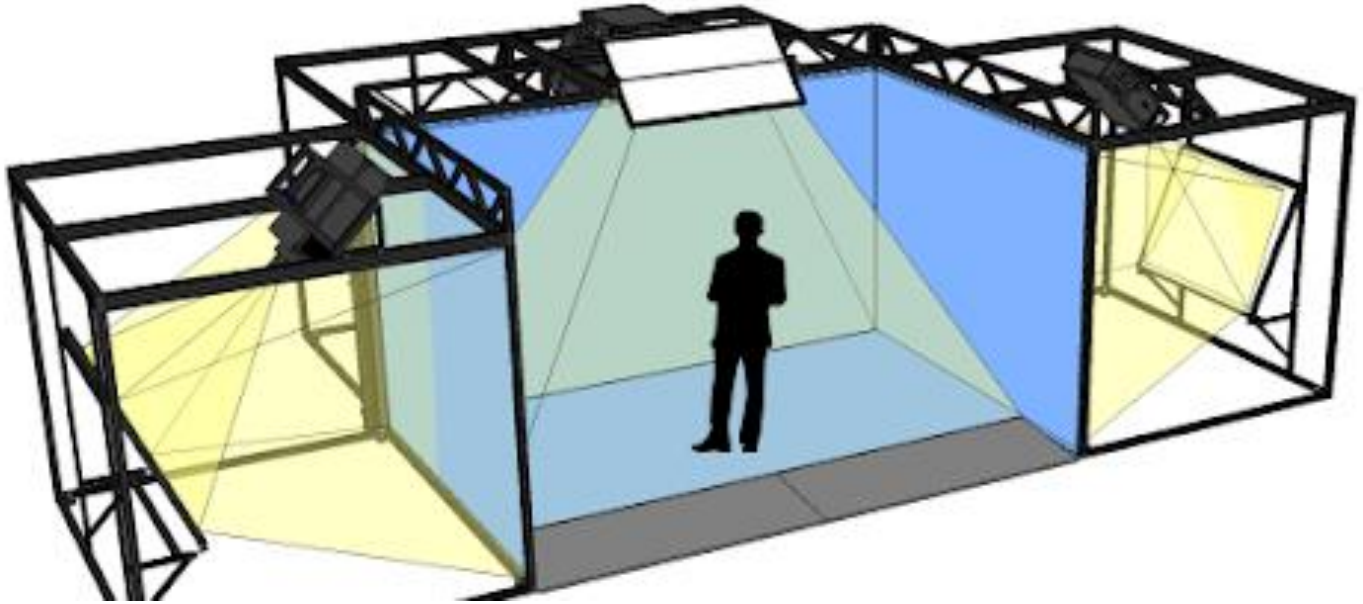
[Field of View (FoV) and Field of Regard (FoR)]()

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

Display Devices

Visual display

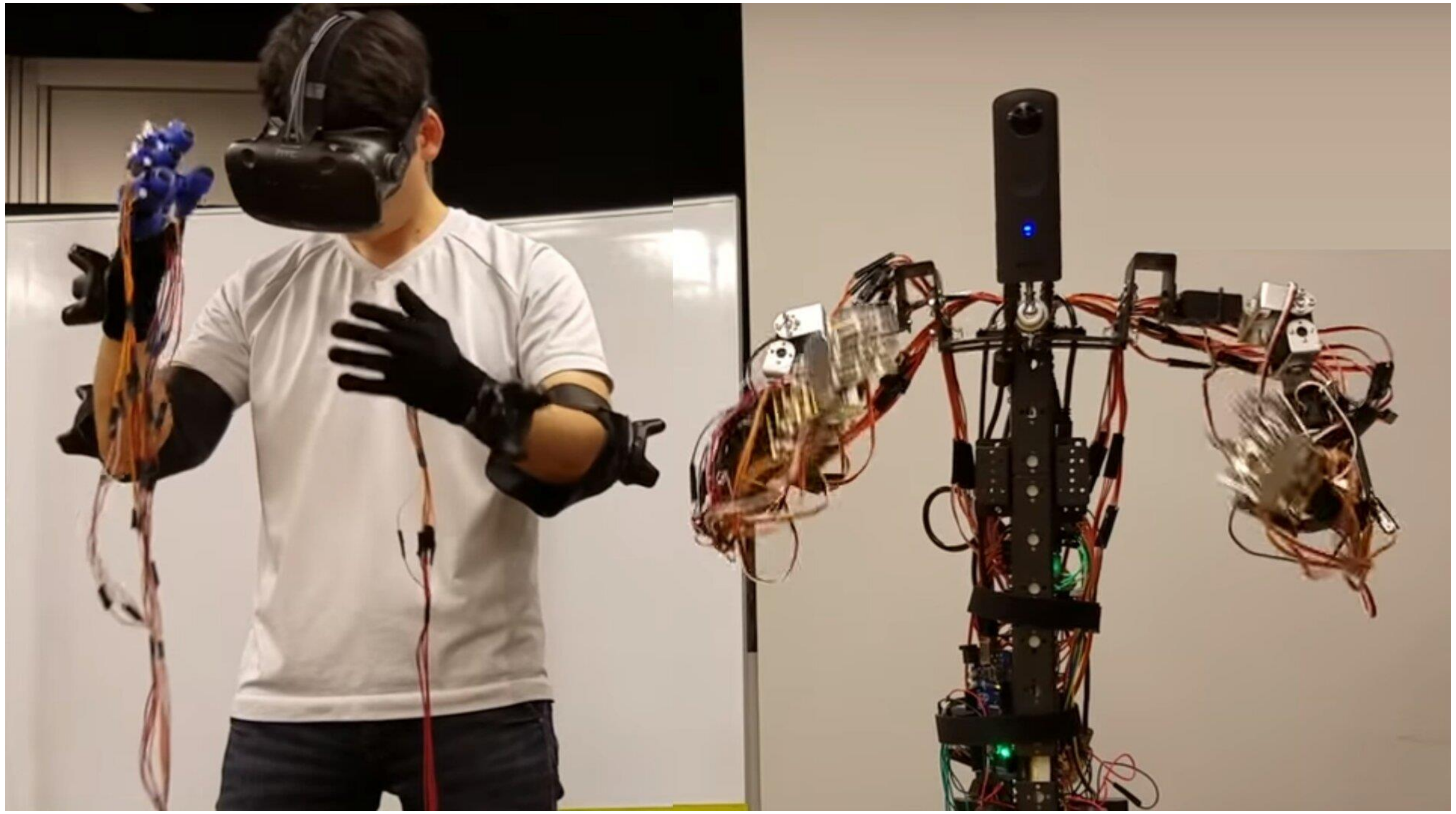
- Stationary display
- Head based display
- Hand based display

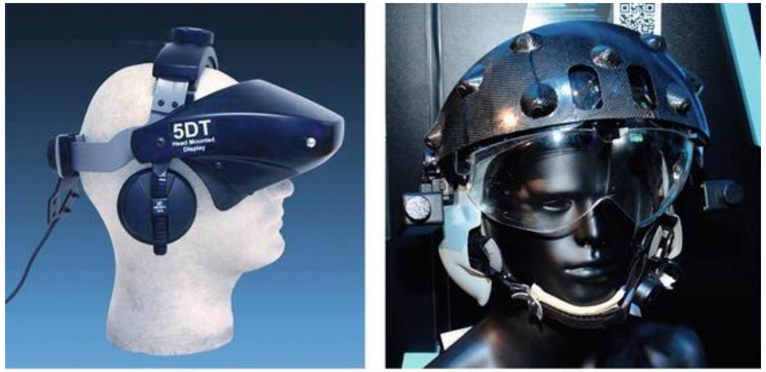


Stationary display

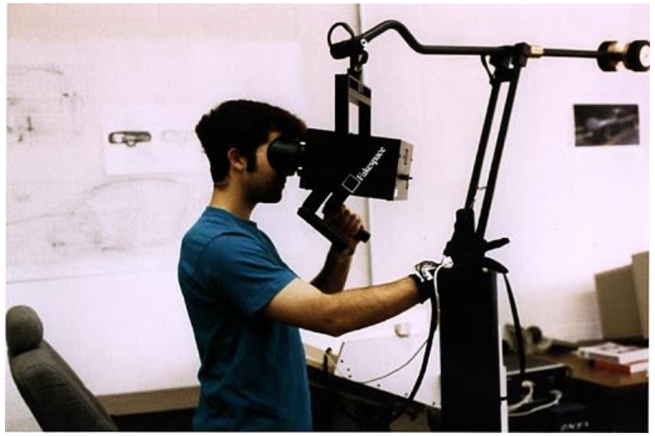
Stationary display –
Desktop display & CAVE

Head Based displays (HBD)

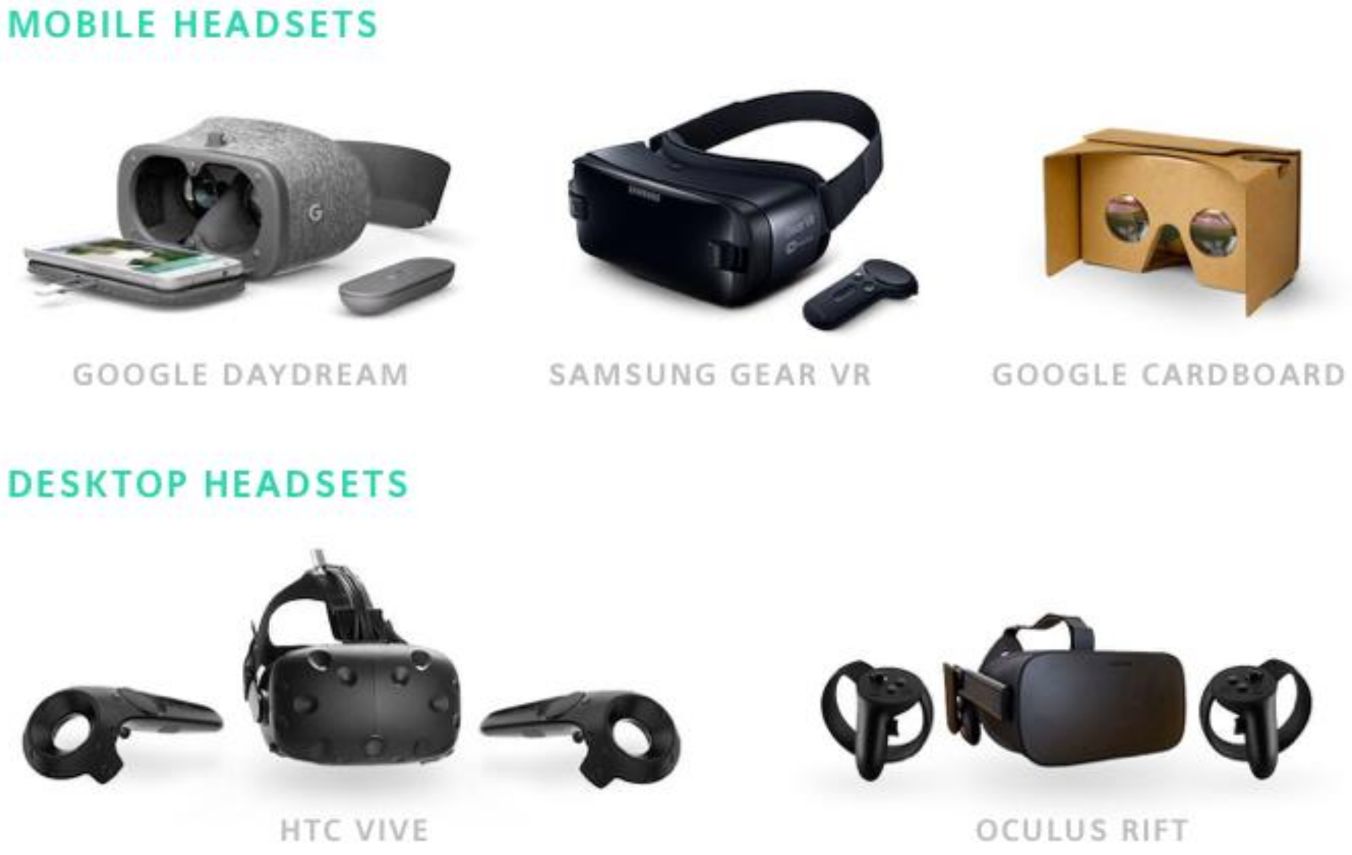




(a) (b)



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

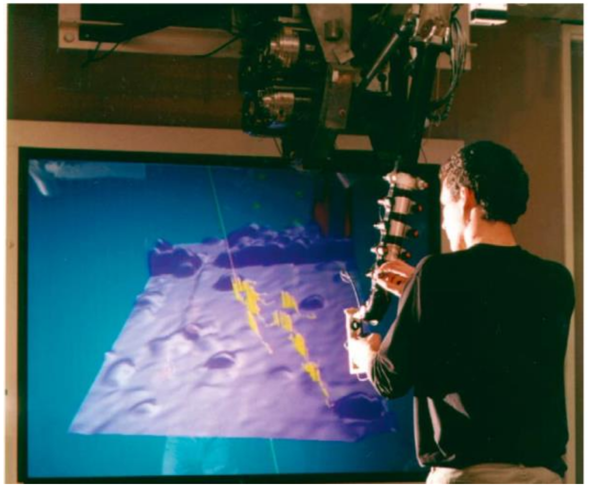
Components:

- 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

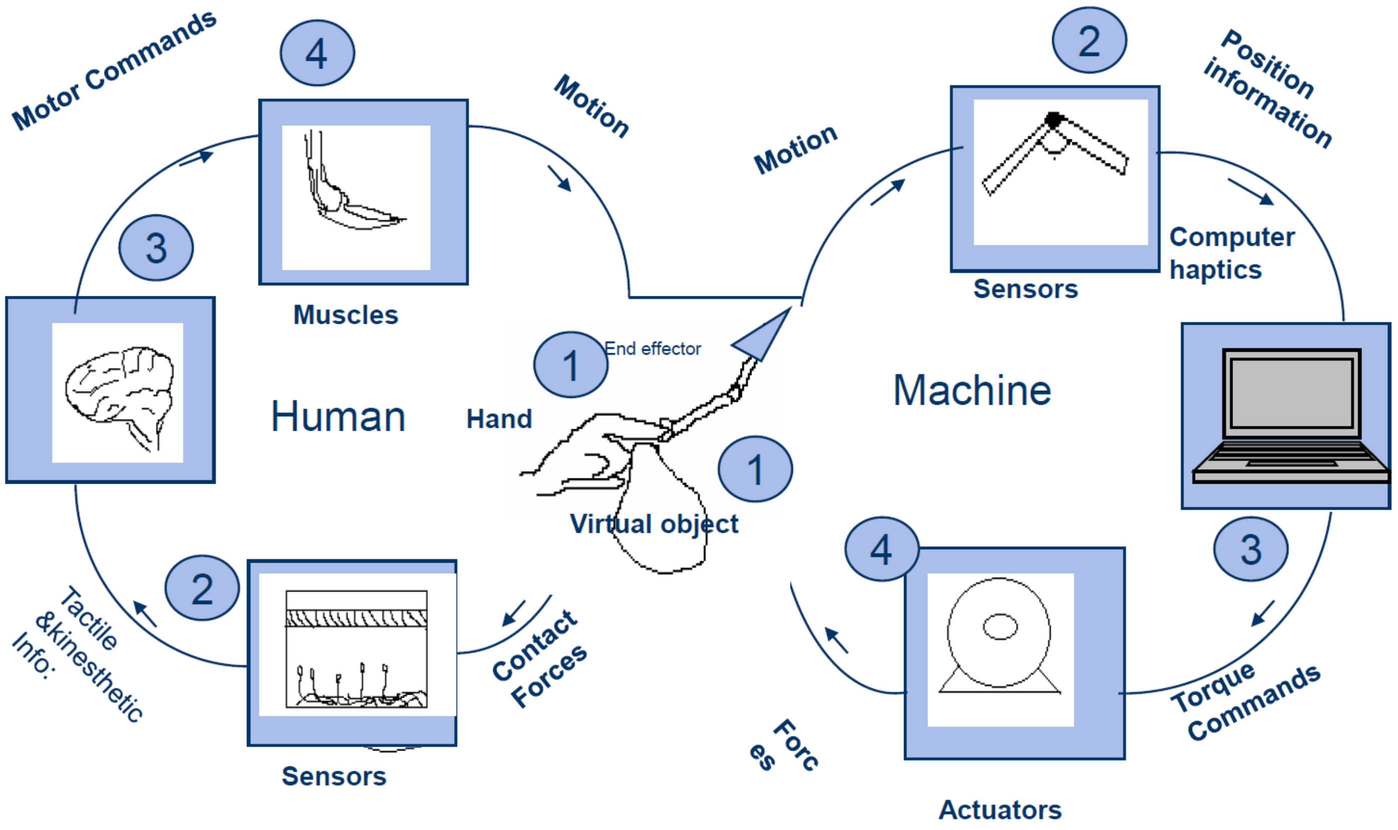
Kinesthetics Information

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 Hepatic 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 Haptic 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

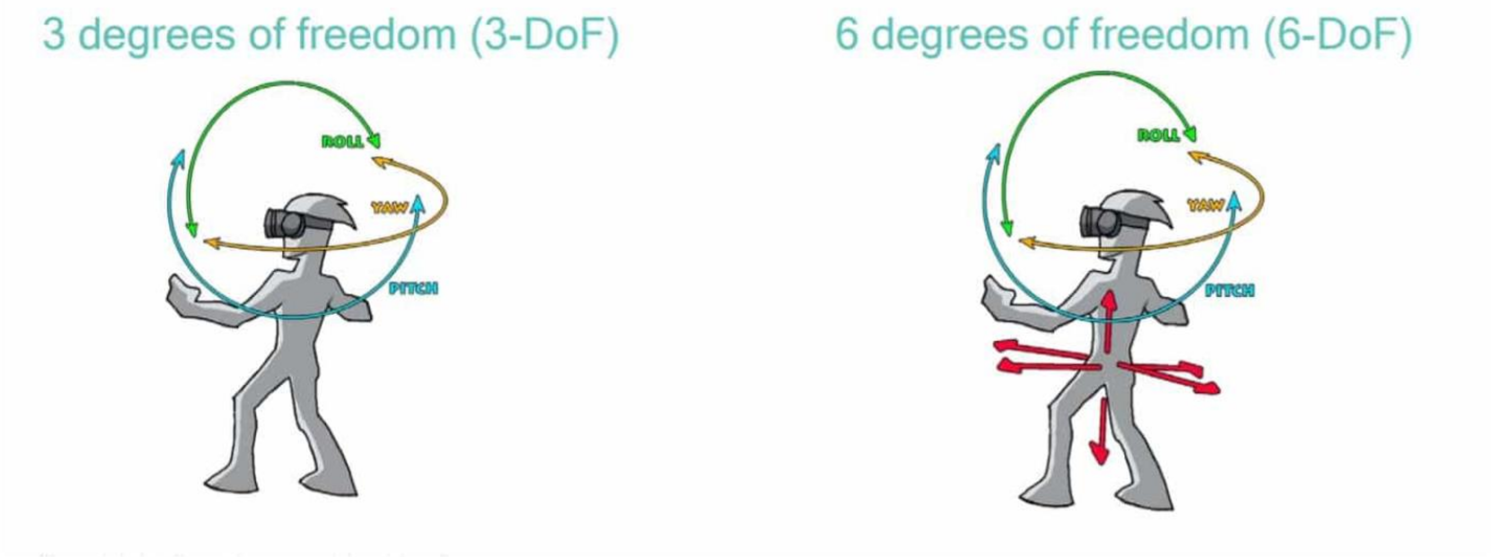
Video – Haptic

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

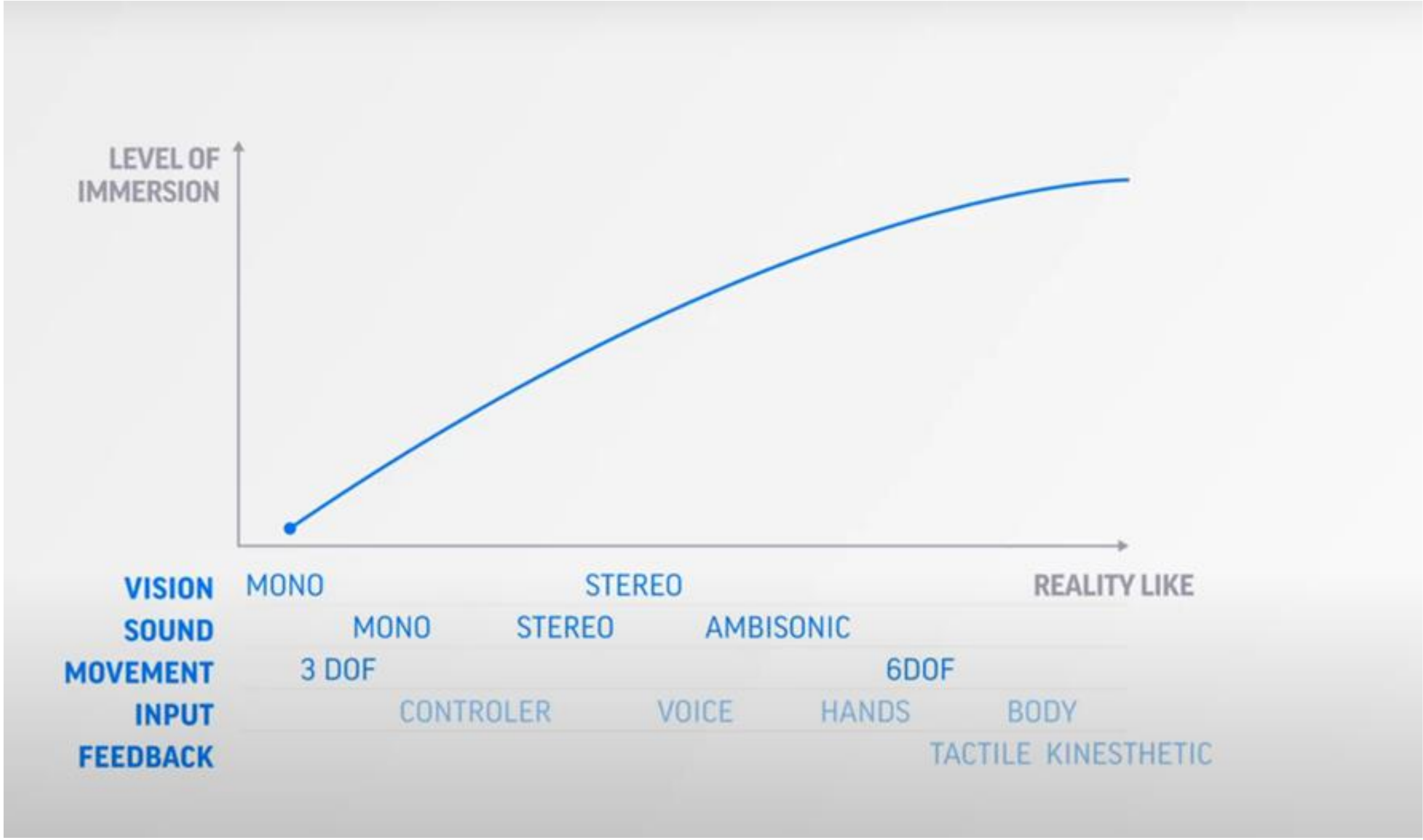


- Degree of Freedom = independent movement about an axis
  - 3 DoF Orientation = roll, pitch, yaw (rotation about x, y, or z axis)
  - 3 DoF Translation = movement along x,y,z axis
- Different requirements
  - User turns their head in VR -> needs 3 DoF orientation tracker
  - Moving in VR -> needs a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

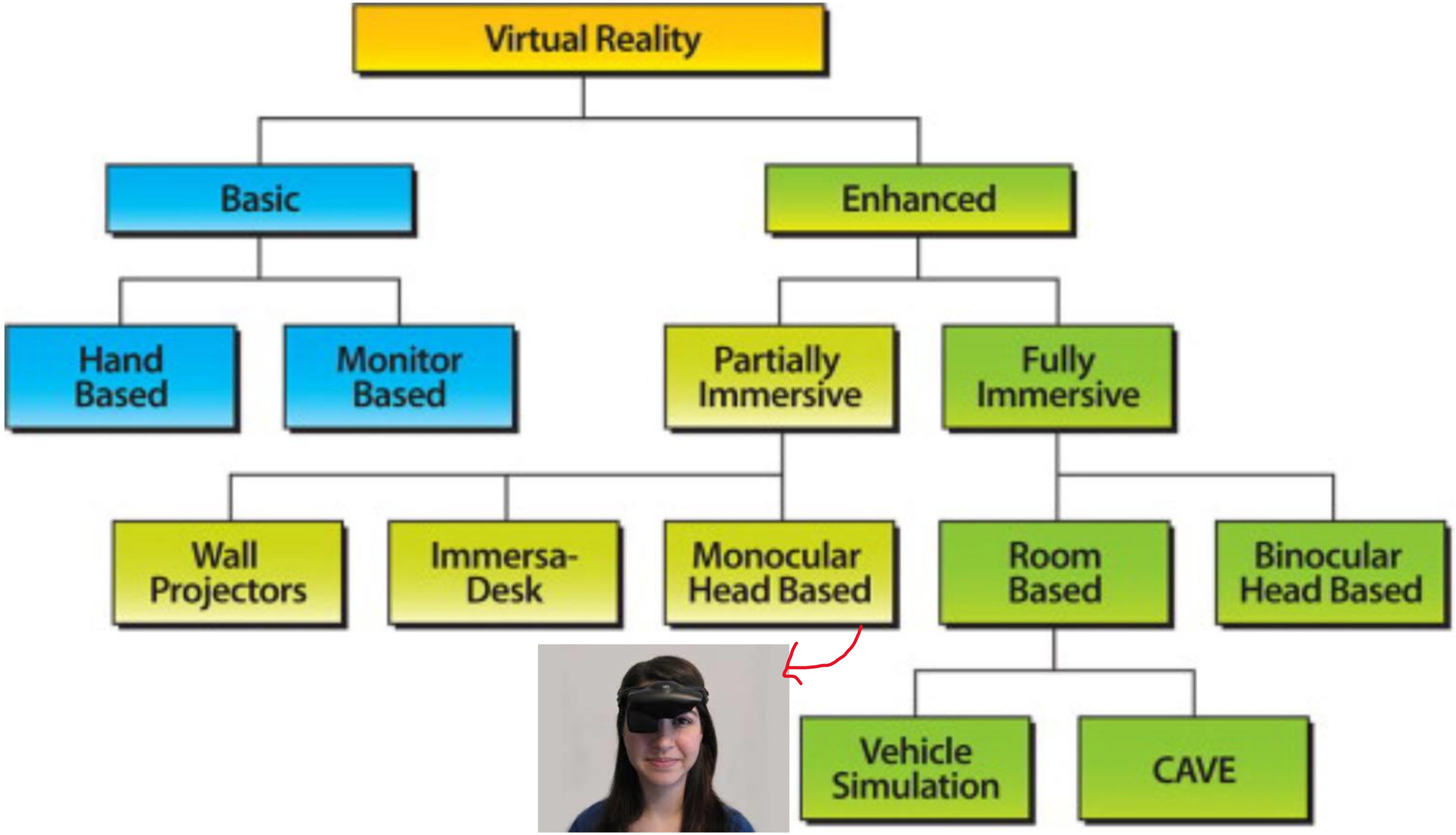
Videos - DoF

- 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

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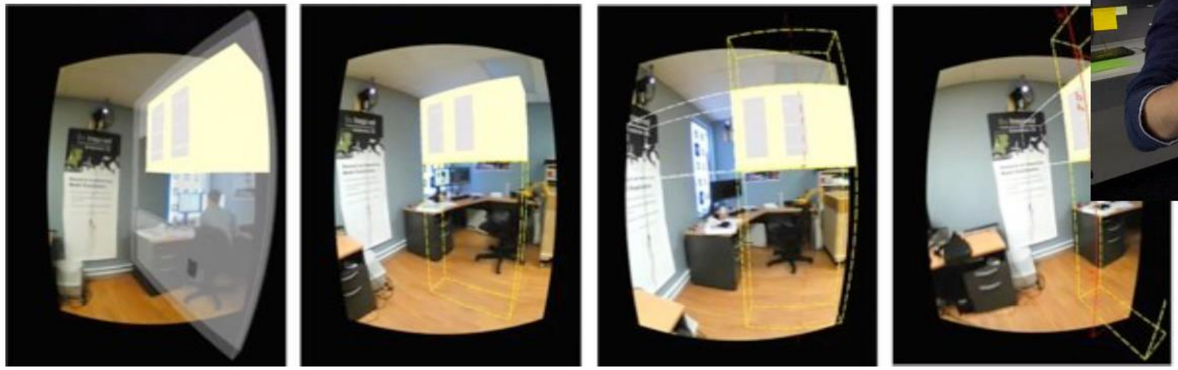
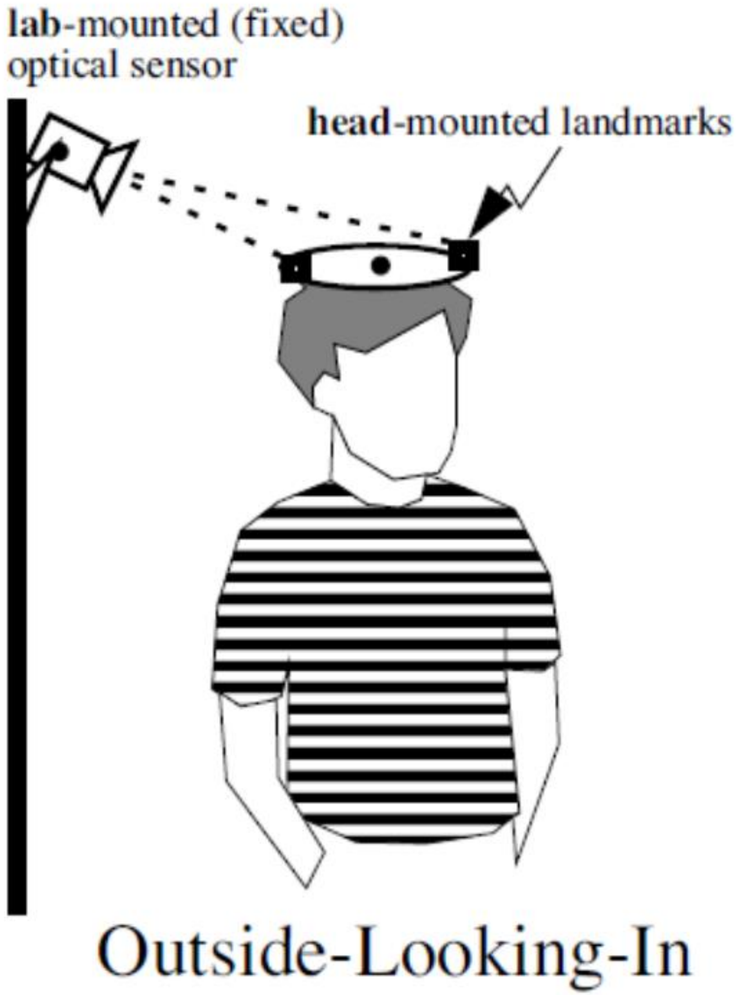
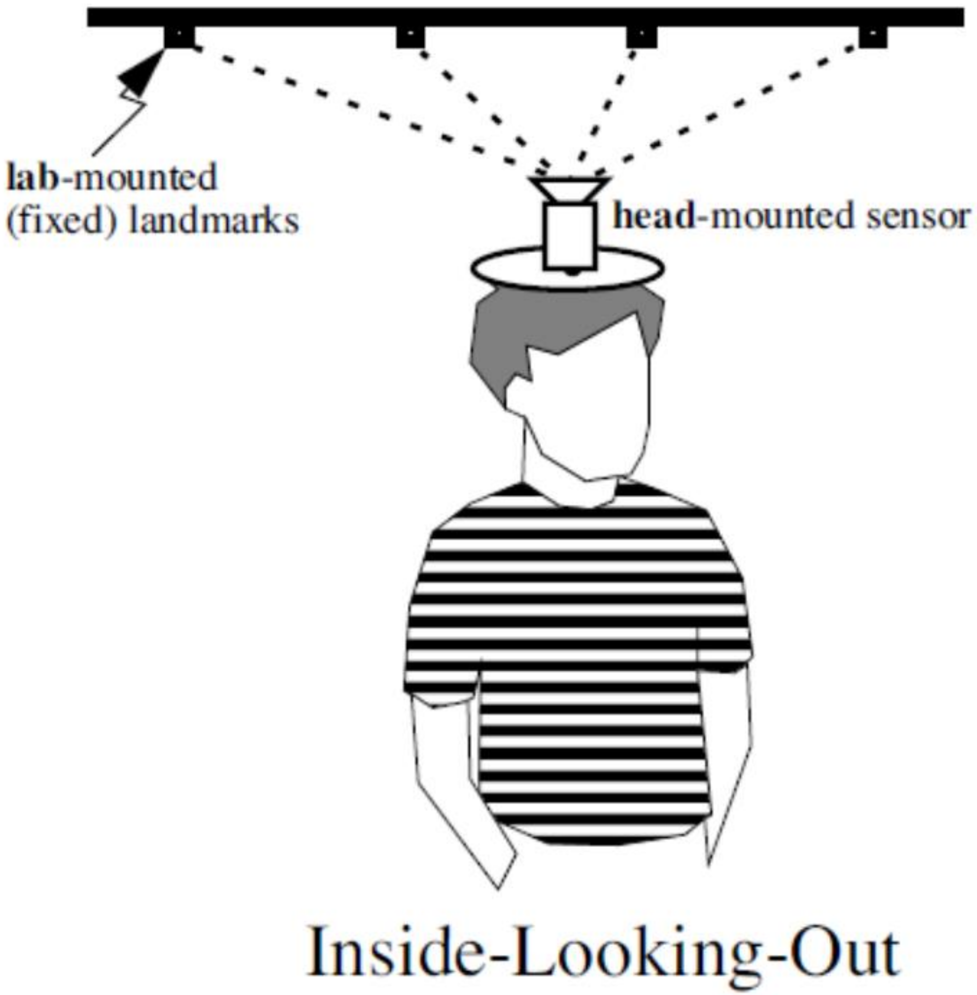
Tracking in VR



- 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

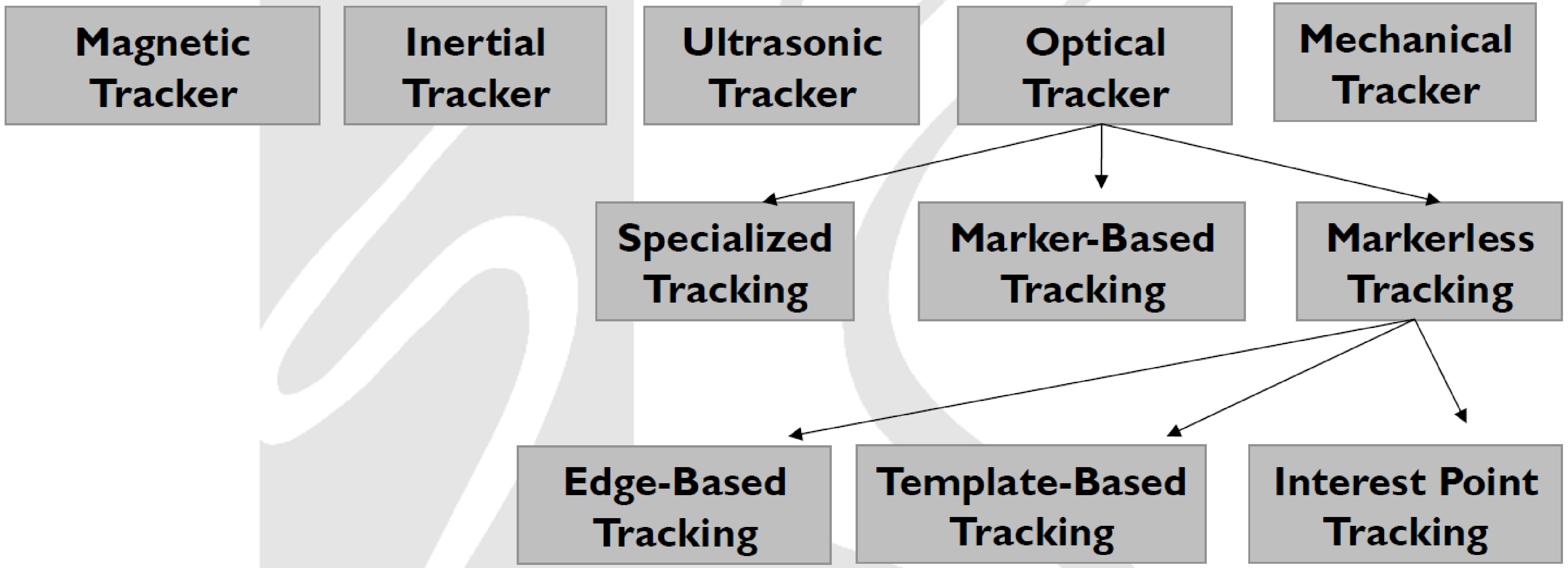




https://www.youtube.com/watch?v=IWYsdHZDNJk&t=60s

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

Tracking Types



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.