VIRTUAL REALITY SYSTEMS

- Virtual reality (VR) us a technology that allows a user to interact with a computersimulated environment, be it a real or imaginary one.
- Most current V R environments are primarily visual experiences, displayed either on a computer screen or through special stereoscopic displays.
- Users can interact with a virtual environment or a virtual artifact either through the use of standard input devices or through multimodal devices such as wired glove, boom arm, omni-directional treadmill etc.
- Simulated environment can be similar to the real world (example: simulation for pilot or combat training) or it can differ significantly from reality (example V R games).
- VR is often used to describe a wide variety of applications, commonly associated with its immersive, high visual, 3D environments

Design of a VR system

- There is always a trade-off between realism and interactivity.
- The more realistic a scene must appear, the longer it takes to render and the slower the virtual environment will update.
- Detailed images make a virtual environment appear more realistic, but movement through the environment is slow and cumbersome.
- Lesser-detailed scenes will appear false and artificial, but movement through the environment is smooth and faster.
- A VR system consists of six main components: the virtual world, graphics engine, simulation engine, user interface, user inputs, and user outputs.
- A virtual world is a scene database that contains geometric representation and attributes for all objects within the environment.
- The graphics engine is responsible for generating the image that a viewer sees.
- The simulation engine does most of the work required to maintain a virtual environment.
- The user interface controls how the user navigates and interacts with this virtual environment.

Important factors in a V R system

a) **Visual realism:** The level of realism in a scene aids considerably in making a believable environment. Ray tracer and professional animation systems produce realistic images used in special effects for movie production.

b) **Image resolution:** Image resolution is another factor that is closely linked with visual realism. Computer-generated images consist of discrete picture elements of pixels, the size and number of these being dependent on the display size and resolution.

c) **Frame rate:** To give the impression of a dynamic picture, the system updates the display very frequently with a new image. In order for a virtual environment to appear flicker free, the system must update the image greater than 20 times each second.

d) **Latency:** It is the most important aspects pf a VR system that must be addressed to make the environment not only more realistic but also tolerable. It is the delay induced by various components of a VR system between a user’s input and the corresponding response from the system in the form of a change in the display.

Types of VR system

1. Window-on-world (or desktop) VR:

• It is the most common and accessible form of V R system.
• It involves displaying a 3D virtual world on a regular desktop display without using a specialized movement-tracking equipment
• The system do not rely on any specialized input or output devices in order to use them.
• A user can interact with that environment, but is not immersed in it.

2. Video mapping VR:

• A video mapping VR uses cameras to project an image of a user into a computer program.
• Monitoring the user with a video camera provides another form of interactive environment. The computer identifies the user's body and overlays it upon a computer generated scene.
• By gesturing and moving around in front of the camera, the user can interact with the virtual environment

3. Immersive VR:

• An immersive VR uses an head mounted display (HMD) to project a video directly in front of the user's eye, plays audio directly into the user's ear, and tracks whereabouts the user's head.
• A data glove (or data suit) is used to track movement of the user's body and then duplicates them on the virtual environment

4. Telepresence:

• It is a technology that links remote sensors in the real world with the senses of a human operator.

• It links remote sensors and cameras in the real world with an interface to a human operator.

• The operator can see the environment that the robot is in and can control its position and actions from a safe distance.

• Example: use of remote robots in bomb disposal, use of remotely-operated vehicles by fire fighters, use of small instruments on cables by the surgeons etc.

5. **Augmented reality:**

• An augmented (or mixed) reality provides a half way point between a non immersive and fully immersive VR system.

• Here the computer-generated inputs are merged with the telepresence inputs and the users view of the real world.

• Example: Head-up displays (HUD) used in modem military aircraft.

6. Fish tank VR:

• It is used to describe a hybrid system that incorporates a standard desktop VR system with a stereoscopic viewing and head-tracking mechanism.

• The system uses LCD shutter glasses to provide the stereoscopic images and a head-tracker that monitors the user's point view on the screen.

Advantages of Virtual reality

- It gives disabled people the opportunity to join the activities not usually available to them.
- V R has very important uses in all types of architecture and industrial design.
- Computer-aided design (CAD) has been an important design tool because it allows the user to draw 3D images on a computer screen.

Input and output devices for Virtual reality

a) **Three-dimensional position trackers:** Tracking devices allow a V R system to monitor the position and orientation of selected body parts of a user. In tracking devices, such as HMDs, the position and orientation of the head is measured. A tracking device attached to a glove measures the position and orientation of a hand. Tracking devices, also called 6-degree-of-freedom (6DOF) devices, work by measuring the position (x, y, and z coordinates) and the orientation (yaw, pitch and roll) with respect to a reference point or state. In terms of hardware, three components are in general required: a source that generates a signal, a sensor that receives the signal, and a control box that processes the signal and communicates with the computer. The special purpose hardware used in virtual reality to measure the real-time change in a 3D object position and orientation is called a tracker.

i) **Mechanical trackers:** It is similar to a robot arm and consists of a jointed structure with rigid links, **a** supporting base, and **an** " active end" that is attached to the body part being tracked. These trackers are fast, accurate and not susceptible to jitter. It has a restricted area of operation so tracking of two body parts at the same time is difficult

ii) Electromagnetic trackers: Electromagnetic tracker or magnetic tracker allows several body parts to be tracked simultaneously and functions correctly if objects come between the source and detector. In this type of tracker the source produces three electromagnetic fields each of which is perpendicular to the other. **The detector on the user's body** measures field attenuation **(strength and** direction of the electromagnetic field) and sends this information back to a computer. These trackers are popular but they are inaccurate. They suffer from latency problems, distortion of data and by large amount of metals. The detector must be within a restricted range from the source, so the user has a limited working volume.

iii) Ultrasonic trackers: An ultrasonic tracker is a noncontact position measurement device that uses an ultrasonic signal produced by a stationary transmitter to determine the real-time position of a moving receiver element. There are two ways to calculate position and orientation: phase coherence and time-of-flight. Unlike electromagnetic trackers that are affected by large amounts of metal, ultrasonic trackers do not suffer from this problem. Ultrasonic trackers must have a direct line-of-sight from the emitter to the detector. These trackers are affected by temperature and pressure changes and the humidity level of the work environment

iv) Infrared trackers: IR (optical) trackers are a class of optical tracker, which is a noncontact measurement device that used optical sensing to determine the real-time position or orientation of the object This type of tracker is not affected by large amount of metal, has a high update rate and low latency. The emitters used here must be directly in the line-of-sight of the camera. Any other sources of IR light, high-intensity light, or other glare affect the correctness of the measurement

Navigation and manipulation interfaces: Manipulation tasks involve selecting and moving an object. Users need to be able to manipulate virtual objects which includes rotation also. Navigation tasks has two components. Travel involves moving from the current location to the desired point Wayfinding refers to finding and setting routes to get to a travel goal within the virtual environment. There are three types if travel tasks: exploration, search and maneuvering. Travel techniques can be classified into the following five categories:

- Physical movement: user moves through the virtual world
- Manual viewpoint manipulation: use hand motions to achieve movement
- Steering: direction specification
- Target-based travel: destination specification
- Route planning: path specification

c) **Gesture interfaces:** Navigation and manipulation interfaces limit the freedom of the motion of users to small area or desktop leading to sacrificed and less intuitive virtual world. The solution to this problem is the gesture interfaces. These devices measure the real-time position of the user's fingers or wrist in order to allow natural gesture based interaction with the environment Gesture recognition is useful for processing information from humans, which is not conveyed through speech. Some of the available gesture device include Fakespace PINCH Gloves, 5DT Data Glove and Immersion CyberGlove etc.

d) Graphics interfaces: Graphic displays, displays with tracked stereo glasses, glassless displays, multi-projector screen systems and sound display systems are important class of output devices in a virtual environment.

i) HMD: It is a computer display we wear on our head. Engineers design HMDs to ensure that no matter in what direction a user might look, the monitor should stay in front of his eyes. The monitors in an HMD are most often LCD. Any HMDs include speakers or headphones so that it can provide both video and audio output. HMDs almost always include a tracking device so that the point of view displayed in the monitor changes as the user changes his head,

ii) **Cave-automatic virtual environment (CAVE):** It is a display that uses tracked stereo glasses to feel the environment. It is a small room or cubicle, where at least three walls (and sometime the floor and ceiling) act as giant monitors. The display gives the user a very wide field of view. The user can also move around in a CAVE system without being tethered to a computer. Tracking devices attached to the glasses tell the computer how to adjust the projected images as we walk around the environment.

e) Sound interface: Sound effects are often used to communicate important information in video games. This may produce mono, stereo, or 3D audio. Mono sends one signal to every speaker. A stereophonic sound allows for the sounds to seem as if they are coming from anywhere between two speakers. Research into a 3D audio has shown that there are many aspects of our head and earshape affecting the recognition of 3D sounds. It is possible to apply a rather complex mathematical function called head-related transfer function (HRTF) to a sound to produce this effect

f) Examples of input devices: VR requires a different set of user input tools than traditional computers. There are examples of input devices that have been developed for use with virtual reality.

i) G love, Data Glove ad Power Glove: A glove device is designed specifically for capturing the movement and location of the hand. W hen we move our hand, the glove picks up the movement and sends an electrical signal to the computer that translates the movement from the real space into the virtual space.

A Data Glove is made of lightweight lycra that consists of two measurement tools. The first tool measures the fled and extension of every finger. The second tool measures the absolute position (x, y, and z axes) and
orientation (roll, pitch, and yaw) of the hand. This tool has two parts: a stationary transmitter and a receiver, which are placed on the glove.

A Power Glove is a low-cost version of Data Glove that performs the same function using completely different methods. For flex-measuring, the Power Glove has a strip of mylar plastic coated with electrically conductive link.

Like Data Glove, the Power Glove needs calibration for different users. It is less accurate than Data Glove. However, then Power Glove is more rugged and easier to use than the Data Glove.

ii) Dexterous hand master: A dexterous hand master (DHM) is an exoskeleton that is attached to the fingers using Velcro straps, and attached to each finger joint is a device called a half effect sensor, whose purpose is to measure the finger-join angle. DHM uses mechanical linkages to track the movement of the hand. DHM is more accurate than a Power Glove or a Data Glove. It is also able to measure the side-to-side motion of each finger. Because of its precision it is extremely useful for any application that requires a high level of control such as controlling dexterous robotic hands. DHMs are less sensitive than either Data Glove or a Power Glove. However, a DHM is rather clunky to work with.

iii) Mouse and joysticks: These are sufficient for navigating around a simple virtual world in two dimensions and for performing simple tasks by using the buttons on the devices. Mouse and joysticks usually have two degrees of freedom, although there are mouse designed with six degrees of freedom.

iv) Wands: A wand is like a joystick with an unrestrictive base that has 6DOF. There are buttons on a wand and a thumbwheel that allows scalable values to be entered. It can be represented as a drill, paint-brush, spray gun or even an ice-cream cone. A wand is very easy and intuitive to use.

v) Force (space) balls: A force ball has a ball on which force is applied. The force we apply is picked up by sensors in the center of the ball from where the information is then relayed to the computer. A force ball has 6DOF. It is easy and intuitive to use. A force ball requires very little space as there is no movement. Most force balls have programmable buttons for a developer to configure to suit the needs of the application. Uses of a force ball are limited to navigation and selection or issuing commands.

vi) Biological input sensors: Biosensors are a neural interface technology that detect nerve and muscle activity. Currently, biosensors are used in measuring muscle electrical activity, brain electrical activity, and eye movement. Just as the brain uses the signals to control functions of a human body, these signals can be detected by biosensors and then interpreted by software to control electronics devices, external to the human body.

g) Haptic feedback: Haptic technology or haptics is a tactile feedback technology. It makes vibrations and movements which can make people think that there is a real object when there is not. They are used to look into the sense of touch. Some video games use this to make it seem more real. Haptic recreates the sense of touch by applying forces, vibrations, or motions to the user. This mechanical stimulation can be used to assist in the creation of virtual objects in a computer simulation, to control such virtual objects, and to enhance the remote control of machines and devices (tele robotics). Haptic devices may incorporate tactile sensors that measure forces exerted by the user on the interface.