BY: Mukunda paudel
paudelmuku@gmail.com

COMPUTER GRAPHICS

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Unit 9: Introduction to Virtual Reality

What VR is not?

VR is not just any form of Computer Graphics

What VR is:

"Reality that does not exist" (i.e. creating the illusion of reality)

"*The subjective experience of being in one place or environment even when physically situated in another"* **– Witmer, B.G, & Singer, M.J (1998)**

Goal of VR is to make it feel like you are actually in a place that you are not. – ***Palmer Luckey, Co-founder of Oculus***

Virtual Reality (VR) technology helps to realize the impossible. User can experience anything at any place and any time. This immersive technology can induce the human brain into believing about a virtual world.

Virtual reality is a technology that takes the users to a 3D artificial environment using a blend of interactive software and hardware. This 3D virtual environment allows the user to interact with people and objects using large images and appropriate audio devices.

It enables users to experience the information that is immediate and dynamic. The user dons special earphones, goggles and gloves to experience the virtual reality technology. All these devices pass on their data to computer systems.

- VR A system for providing an interactive exploration of a three dimensional virtual environment
- The use of 3D graphics displays to explore a computer generated world
- VR is An advanced form of human computer interface
- Virtual Reality (VR) is the use of computer technology to create a simulated environment.
- Virtual Reality's most immediately-recognizable component is the head-mounted display **(HMD).**
- Human beings are visual creatures, and display technology is often the single biggest difference between immersive Virtual Reality systems and traditional user interfaces.

VIRTUAL WORLD:

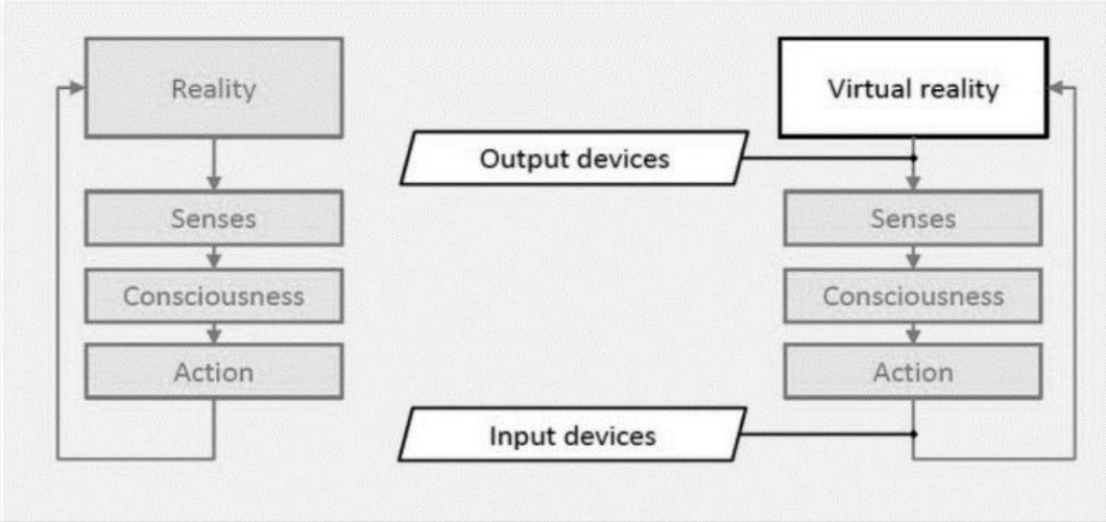
- A scene database containing the geometric representations and attributes for all objects within the environment

How Virtual Reality (VR) Technology Works

- The primary aim of Virtual Reality is to stimulate the vision. Every VR device place one or two screens in front of users' eyes and thus eliminates any possible real world interaction.
- Two lenses that are auto focused, are placed in between the eyes and the screen. These adjust depending on the positioning and eye movement of the user. On screen visuals are rendered through HDMI cables or mobile phones.
- There are certain criteria for creating a true immersive experience: a minimum 60fps frame rate (*the number of images processed per second by GPU*), good refresh rate and a 100 degree view of the field (*the degree to which head and eye movement are supported)*.
- Any discrepancy in these factors may lead the user to experience latency. A response time of 20milliseconds or less is required to trick our brain to believe the VR.
- Cyber sickness or tearing is another cause of concern in VR technology. It results due to inconsistency between refresh rate and frame rate and will lead to distorted images.
- This can be countered by limiting the frame rate to the refresh rate of monitor. Vertical Sync is the technology used in this regard.

VIRTUAL REALITY SYSTEMS

Reality vs. Virtual Reality



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

A typical VR system consists of ***six* main components** grouped into two:

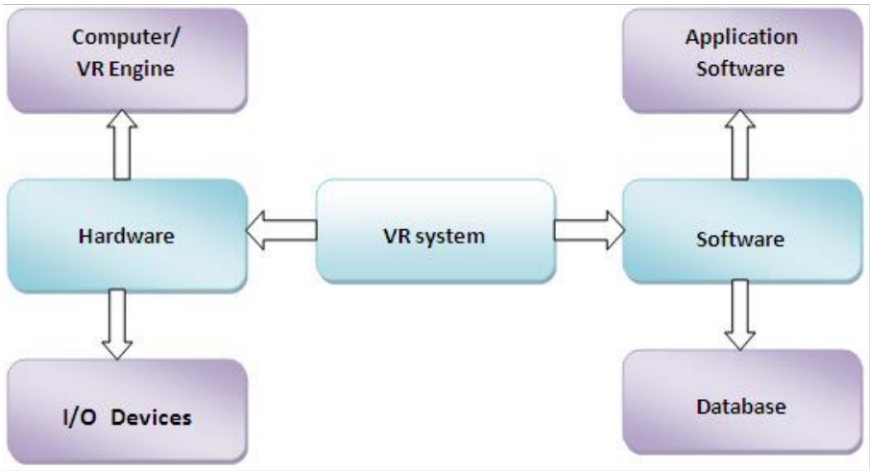


Figure: Generic Components of VR System

1. Internal Components:

i. Virtual world

- A scene database containing the geometric representations and attributes for all objects within the environment.
- It is a 3D environment that is mostly realized through rendering, displays or other such mediums.
- It allows user interactions that mimic real world experience. Here, visual perspectives are highly responsive to movement changes.

ii. Graphics Engine (VR Engine)

- Responsible for actually generating the image or scene, which a viewer will See
- Usually the scene database and the viewer's current position and orientation is taken into account
- It also includes other information form the scene data base e.g. sounds, special effects textures etc.

iii. Simulation Engine

- Does most of the wok required to maintain virtual environment
- Concerned purely with the dynamics of the environment
  - how it changes over time
  - how it responds to the user's actions
- This includes handling interactions, physical simulations (gravity, inertia)

iv. User interface

- Controls how the user navigates and interacts with this virtual environment

2. External Components:

i. User inputs (Input Devices)

- The input devices are the means by which the user interacts with the virtual world.
- They send signals to the system about the action of the user, so as to provide appropriate reactions back to the user through the output devices in real time.
- They can be classified into tracking device, point input device, bio-controllers and voice device.
- Tracking devices sometimes referred to as position sensors, are used in tracking the position of the user, and they include, electromagnetic, ultrasonic, optical, mechanical and gyroscopic sensors, data gloves, neural and bio or muscular controllers.

ii. User outputs (Output Devices)

- The output devices get feedback from the VR engine and pass it on to the users through the corresponding output devices to stimulate the senses.
- The possible classifications of output devices based on the senses are: graphics (visual), audio (aural), haptic (contact or force), smell and taste. Of these, the first 3 are frequently used in VR systems, while smell and taste are still uncommon.
- Two possible common options for the graphics are the stereo display monitor, and the HMD which provides a higher level of immersion.
- In the HMD, the two independent views produced are interpreted by the brain to provide a 3D view of the virtual world.

Architecture of VR System

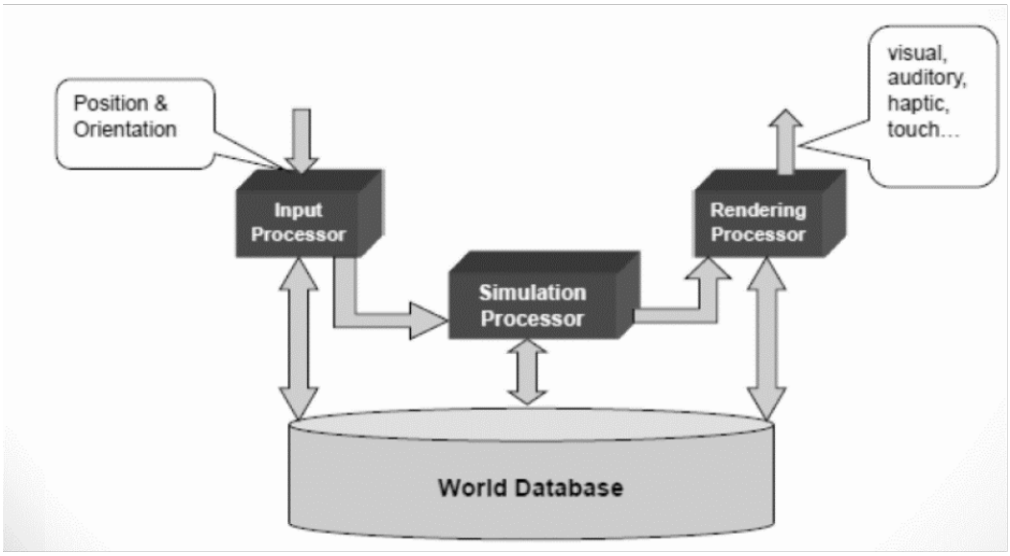


Figure: architecture of a simple VR system

VR system consist of Input Processor, Simulation Processor, Rendering Processor and World Database.

Input Processor

- Control the devices used to input information to the computer. The object is to get the coordinate data to the rest of the system with minimal lag time.
- Keyboard, mouse, 3D position trackers, a voice recognition system, etc.

Simulation Processor

- Core of a VR system.
- Takes the user inputs along with any tasks programmed into the world and determine the actions that will take place in the virtual world.

Rendering Processor

- Create the sensations that are output to the user.
- Separate rendering processes are used for visual, auditory, haptic and other sensory systems. Each renderer take a description of the world stat from the simulation process or derive it directly from the World Database for each time step

World Database (World Description Files)

- Store the objects that inhabit the world, scripts that describe actions of those objects.

3D Position Trackers

- **Positional tracking** detects the precise position of the head-mounted displays, controllers, other objects or body parts within Euclidean space.
- Positional tracking registers the exact position due to recognition of the rotation (pitch, yaw and roll) and recording of the translational movements.
- Since virtual reality is about emulating and altering reality it's important that we can track accurately how objects (like the head or the hands) move in real life in order to represent them inside VR. Defining the position and orientation of a real object in space is determined with the help of special sensors or markers.
- Sensors record the signal from the real object when it moves or is moved and transmit the received information to the computer

3D Position Trackers

- Wireless tracking
- Optical tracking
- Tracking With Markers
- Marker less Tracking
- Inertial Tracking

- Sensor Fusion
- Acoustic Tracking
- Magnetic Tracking

Devices Used in Virtual Reality Technology

- Below mentioned are some of the common VR devices used today.
    - Head mounted displays (HMDs)
    - Immersive rooms
    - Data gloves

Types of Virtual Reality (VR) system

- VR systems can be classified into 3 major categories based on the important features of VR, which is immersion and the type of interfaces or components utilized in the system.
    1. non-immersive
    2. immersive and
    3. semi-immersive

Non-Immersive VR system

- Also called Desktop VR system, Fish tank or Window on World System
- The least immersive and least expensive of the VR systems
- It requires the least sophisticated components.
- It allows users to interact with a 3D environment through a stereo display monitor and glasses, other common components include space ball, keyboard and data gloves.
- Its application areas include modeling and CAD systems

Immersive VR system

- The most expensive and gives the highest level of immersion
- its components include HMD, tracking devices, data gloves and others, which encompass the user with computer generated 3D animation that give the user the feeling of being part of the virtual environment.
- One of its applications is in virtual walk-through of buildings.

Semi-Immersive VR system

- Also called hybrid systems or augmented reality system
- It provides high level of immersion, while keeping the simplicity of the desktop VR or utilizing some physical model.
- Example of such system includes the CAVE (Cave Automatic Virtual Environment) and an application is the driving simulator.

Distributed VR System

- Also called Networked-VR
- It is a new category of VR system, which exists as a result of rapid development of internet.
- Its goal is to remove the problem of distance, allowing people from many different locations to participate and interact in the same virtual world through the help of the internet and other networks.
- A traditional application of this is the SIMNET which is a real time distributed simulation developed by the US military and used for combat trainings

APPLICATIONS OF VR

- VR has found vast applications in many fields due to its characteristics and the benefits it provide in solving complex real-world problems.

Some of the application areas include:

- ✓ Architecture
- ✓ Arts
- ✓ Business
- ✓ Design and Planning
- ✓ Education and Training
- ✓ Entertainment
- ✓ Manufacturing
- ✓ Medical and
- ✓ Scientific Visualization.

In manufacturing, VR is used to remove limitations in virtualization and interaction associated with traditional 3D CAD/CAM systems through virtual manufacturing.

Virtual manufacturing is virtual product design, modeling, simulation, assembly, testing and analysis for error before physical prototypes are built to reduce development time and avoid wasteful costs

Engineering and design

- CAD and CAM
- View products as it would be seen when manufactured

Human factor modeling

- Used to model human behavior in the design of new products or buildings

  E.g. simulation of fire in a building and a user can view how the virtual occupants react to the emergency

- Helps in designing escape strategies, fire modeling, human behavior

Virtual Reality in Automotive Sector

- Engineers are able to experience the look and feel of a car without building multiple prototypes. Safety trials can also be conducted by imitating the outside environment.

Virtual Reality in Healthcare

- Healthcare professionals are able to access virtual models of human anatomy before major surgeries.
- This way, they are better prepared to face any challenges that they might encounter while operating on a real human body.

Virtual Reality in Tourism

- VR provides guided tours of every place in the world. Tourists can experience and explore the grounds before buying destinations.
- Hospitality firms are recreating accommodation experiences using true stimulants like aromas, wind etc.

Visualization

- Data visualization

Simulation

- Flight simulation
- Naval simulation
- Driving simulation

*****End of Chapter*****