CSC209: Computer Graphics

Unit 9 – Introduction to Virtual Reality

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Simulation

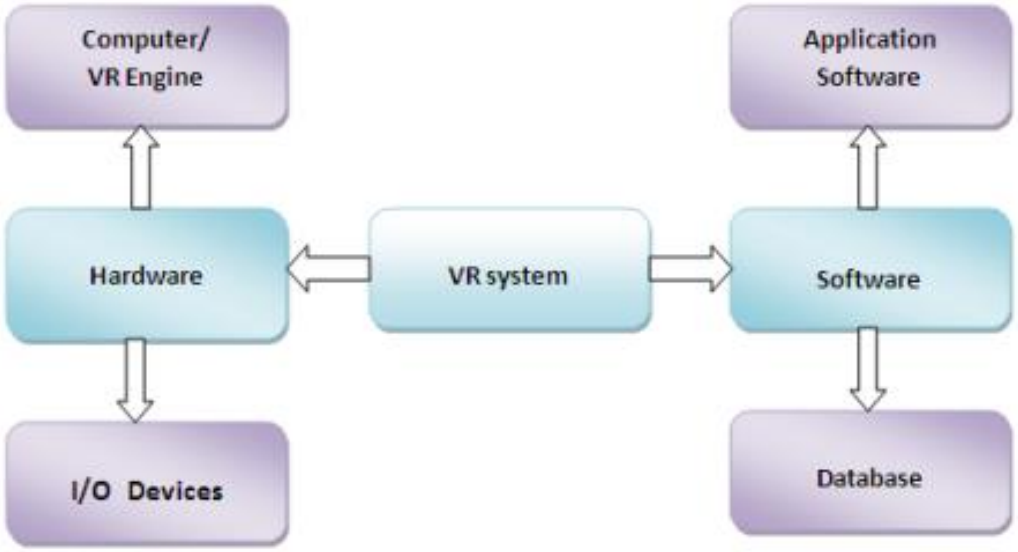
- A representation of a problem, situation, etc. in mathematical terms, using a computer is called simulation.
- Mapping the real-world scenarios into mathematical model using computer graphics.
- Example: Robot Operation Simulation, Training.

Virtual Reality

- Virtual reality is a system for providing an interactive exploration of a three-dimensional virtual environment.
- It refers to a high-end user interface that involves real-time simulation and interactions through multiple sensorial channels.
- Virtual Reality (VR) is the use of computer graphics and other technologies to create a simulated environment in which the user interacts.
- A realistic simulation of an environment, including three-dimensional graphics, by a computer system using interactive software and hardware.
- A computer simulation of a real or imaginary world or scenario, in which a user may interact with simulated objects in real time. Computer simulations that use 3D graphics and devices such as the data glove to allow the user to interact with the simulation.

Components of Virtual Reality

- A VR system is made up of 2 major subsystems, the **hardware** and **software**.
- The hardware can be further divided into computer or VR engine and I/O devices, while the software can be divided into application software and database as illustrated below.



Virtual Reality System Hardware

- The major components of the hardware are the VR engine or computer system, input devices and output devices shown in figure below:

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, 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. Examples of point-input devices include 6DOF mouse and force or space ball. Their technology is an adaptation of the normal mouse with extended functions and capability for 3D.
- Voice communication is a common way of interaction among humans. So, it feels natural to incorporate it into a VR system. Voice recognition or processing software can be used in accomplishing this.

VR Engine

- In VR systems, the VR engine or computer system must be selected according to the requirement of the application. Graphic display and image generation are some of the most important factors and time-consuming task in a VR system.
- The choice of the VE engine depends on the application field, user, I/O devices, level of immersion and the graphic output required, since it is responsible for calculating and generating graphical models, object rendering, lighting, mapping, texturing, simulation and display in real-time.

VR Engine

- The computer also handles the interaction with users and serves as an interface with the I/O devices. A major factor to consider when selecting the VR engine is the processing power of the computer, and the computer processing power is the number of senses (graphical, sound, haptic, etc.) that can be rendered in a particular time frame as pointed.
- The VR engine is required to recalculate the virtual environment very quickly and produce real time simulation, furthermore, the associated graphic engine should be capable of producing stereoscopic vision.
- The VR engine could be a standard PC with more processing power and a powerful graphics accelerator or distributed computer systems interconnected through high-speed communication network.

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.

Output Devices

- 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. Audio or sound is an important channel in VR; its importance is only surpassed by that of visual.
- 3D sound can be used in producing different sounds from different location to make the VR application more realistic.
- Haptic is used to allow the user feel virtual objects. This can be achieved through electronic signals or mechanical devices.

Virtual Reality System Software and Tools

- Virtual reality system software is a collection of tools and software for designing, developing and maintaining virtual environments and the database where the information is stored.
- The tools can be classified into **modeling** tools and **development** tools.

VR Modeling Tools

- There are many modeling tools available for VR designing, the most common ones are , 3ds Max, Maya and Creator.
- Engineering specific applications might use software like CATIA, Pro/E, SolidWorks, UG, etc.

VR Development Tools

- VR is a complex and integrative technology that borrows from many other technologies, such as real time 3D computer graphics, tracking technology, sound processing, and haptic technology, among others, therefore software development flexibility and real time interaction is needed.
- Starting the development of a VR system from the basic codes in C/C++, Java, OpenGL, etc., requires a large amount of work and such system reliability is usually low, therefore VR development tools are used.

VR Development Tools

- Careful consideration is needed in choosing VR development tools due to the difference in flexibility provided by different software packages as related to model input available, interface compatibility, file format, animation ease, collision detection, supported I/O devices and support community available to the users.
- VR development tools used in VR content creation include, virtual world authoring tools, VR toolkits/software development kits (SDK) and application program interfaces (APIs). But it is not uncommon to find that some APIs are also toolkits, like OpenGL optimizer and Java 3D API.

Types of Virtual Reality Systems

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

Non-Immersive VR system

- **Non-Immersive VR system**, also called Desktop VR system, Fish tank or Window on World system is the least immersive and least expensive of the VR systems, as 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 architecture, industrial design , data visualization, modeling and CAD systems.
- Less cost and involves less use of interactive technology.

Immersive VR system

- Immersive VR system on the other hand is 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.
- User has no visual contact with the physical world.
- Example of such system includes the CAVE (Cave Automatic Virtual Environment) and an application is the driving simulator.

Semi-Immersive VR system

- Semi-Immersive VR system, also called hybrid systems or augmented reality system, provides high level of immersion, while keeping the simplicity of the desktop VR or utilizing some physical model.
- Example: Flight Simulator

Distributed VR system

- Distributed-VR also called Networked-VR 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.

3D positional tracking

- Positional tracking is a technology that allows a device to estimate its position relative to the environment around it. It uses a combination of hardware and software to achieve the detection of its absolute position.
- It is an essential technology for virtual reality (VR), making it possible to track movement with six degrees of freedom (6DOF).
- Positional tracking VR technology brings various benefits to the VR experience. It can change the viewpoint of the user to reflect different actions like jumping, ducking or leaning forward.
- It increases the connection between the physical and virtual world.

Navigation and Manipulation Interfaces

- 3D maps such as Google Earth and Apple Maps (3D mode), in which users can see and navigate in 3D models of real worlds, are widely available in current mobile and desktop environments. Users typically interact with computers using a keyboard or mouse and a monitor for display.
- However, because the manipulation method does not mimic actual actions, typical keyboard and mouse interfaces reduce the level of immersion. As a result, they are frequently unsuited for the navigation of 3D maps in virtual worlds.
- Due to their ability to deliver an immersive virtual reality (VR) experience at a reasonable price, head-mounted displays (HMDs) are currently attracting a lot of interest from the industry and consumers.

Navigation and Manipulation Interfaces

- The body motion approach of gesture recognition can offer a greater degree of immersion than the traditional keyboard/mouse method.
- Users must learn the operation method and have time to adjust before the first execution because they use an interface that they are unfamiliar with. However, after a very short learning period, users were able to experience virtual reality more effectively. However, after a very short learning period, users were able to engage with virtual reality more effectively.
- It is more interesting and fun for the user to use his or her body to manipulate 3D space and navigate 3D environments, but the interface method can be different according to the type of scenario space.

Visual computation in Virtual Reality

- Visual computation is a computation that let us interact and control by manipulating visual images either as direct objects or, simply, representations of nonvisual objects.
- The visual images can be images, 3D scenes, videos, block diagrams or simple icons. Visual computation can be broken down into two main branches:
  - Computer environment in which a visual paradigm rather than text paradigm is used.
  - Applications that deal with large or numerous image files, such as video sequences and 3D scenes.

https://www.techopedia.com/definition/16286/visual-computing

Augmented Reality

- Augmented reality (AR) is the integration of digital information with the user's environment in real time. Unlike virtual reality (VR), which creates a totally artificial environment, AR users experience a real-world environment with generated perceptual information overlaid on top of it.
- Augmented reality is used to either visually change natural environments in some way or to provide additional information to users.
- The primary benefit of AR is that it manages to blend digital and three-dimensional (3D) components with an individual's perception of the real world. AR has a variety of uses, from helping in decision-making to entertainment. .

Virtual Reality vs Augmented Reality

Basis	Virtual Reality	Augmented Reality
Purpose	The system replaces reality, completely simulates the virtual environment.	The system adds to reality, augments the real-world environment.
Control of the senses	Visual senses are under the control of the system.	Users have a sense of being in the real world.
Degree of immersion	Users are fully immersed into the action	Users are partially immersed into the action
Device	Special VR devices are needed (headset, gloves, etc.)	No special AR devices are needed (only cameras on a smartphone)
Enhancement target	VR enhances a fictional reality	AR enhances both real and virtual worlds

Applications of VR

- Training & Education
- Entertainment
- Manufacturing
- Medicine
- Visualization
- Engineering and design
- Military