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Chapter 1

Important concepts to virtual reality

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Abstract: The term "virtual reality" (VR) refers to the interaction of a human being with a simulated world that has been produced via the deployment of computing technology, typically incorporating computer graphics and artificial intelligence. "Virtual" refers to anything that is imagined, whereas "reality" refers to something that is true. Within virtual reality, it is possible for a human to physically handle virtual things or animated objects. Many fascinating applications, such as, make advantage of the three-dimensional settings that are produced via the usage of virtual reality. VR includes training for driving automobiles and aeroplanes, as well as computer games and more applications. The word "augmented reality" is another concept that is sometimes mistaken with virtual reality (VR). For example, augmented reality is the incorporation of virtual items into the physical world. With virtual reality (VR), humans are placed in a simulated three-dimensional world, and they are able to truly experience the sound and sight of the three-dimensional scene, creating the illusion that it is a reality. One example of a virtual world is the game in which the main character in the film created, the kid interacts with it using a virtual reality headset and other equipment. This chapter discusses Virtual Reality main concepts, Virtual Reality experience, characteristics and components of a VR system.

Keywords: VR system, VR components, VR system characteristics, VR experience, virtual world.

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1.1 Introduction

With the advent of 3D movies, virtual reality came into being. When Morton was working as a cameraman in 1956, he wanted viewers to feel like they were being themselves in the film. Through the virtual reality (VR) technology that he developed, individuals were able to experience riding a motorbike in the film. They were able to see the road, hear the noises of the engine, feel the vibrations of the wind, and smell the exhaust. In the year 1960, he received a patent for a head-mounted display system (Sutherland, 1968) that he

termed the Telesphere Mask. It was almost seventy years ago that virtual reality (VR) first began its trip, although its origins may be traced back to the 1860s, before the advent of digital technology. During the 1980s and 1990s, it began to garner the attention of the general public generally. There has been a significant amount of progress made since that time.

One definition of VR is "virtual reality" , not only is it not a hallucination, but it is also not a dreaming of imaginings. By putting oneself in either partial, full, or non-immersion in a simulated environment, one may have a fascinating experience of utilising a human-computer interface (Berta, 1999; Bryson, 1993; Adam, J.A.,1993; Lu, 1999; Brooks, 1999). This allows one to feel as if they are in a real world while still experiencing the impacts of the environment. The simulation process and the type of experience that is being provided really include the control of the senses that are being utilised (sight, hearing, taste, touch, and smell, among others) in order to create a simulated environment in the real world through the utilisation of technologically advanced interfaces. In the present moment, there is a major paradigm change. The journey of virtual reality (VR), the various VR interfacing devices (to evaluate and control the simulated sensory channels to the brain) that humans use to interface with computers and smart phones, and the different types of immersive simulations that use a variety of techniques and technologies are all important topics. To begin, there is a need to shed some insight on the meanings of virtual reality (VR), simulation, simulated environment, immersion, and other related terms. Among the pioneering computer scientists, engineers, philosophers, and others who had dedicated their time and research advancements in virtual reality and in its various fields to further develop it are the individuals who have provided these insights. All that is involved is a concentration on the concepts and complexities of a simulated world, as well as the potential for additional progress in the years to come. Education, video games, medical treatments, entertainment (films), defence (army, air force, navy), sports, scientific research, industry, aviation, space, and other similar fields are among the most important applications of virtual reality (VR) (Ottosson, 2002; Gerschütz et al., 2019; Huang et al., 2015; Liu et al., 2018; . Yong, and Huawei, 2018; Lau, and Lee, 2015; West et al., 2018; Thalen, and van der Voort, 2012). After conducting a significant amount of study in a certain field, both computer scientists and engineers are able to develop a simulated environment in an inventive manner, regardless of the application of the simulated environment. The term "simulation" refers to the process of creating a near-near reproduction of real-world physical items and their attributes (such as size, colour, weight, breadth, height, and so on) in a real-world setting while the simulation is taking place in real time. The mathematical representation of the items in a three-dimensional appearance and sensation is what is meant by the term "virtual environment," which is another name for the simulated environment. There were a great number of people who had made contributions

to virtual reality (VR), but according to the records, the phrase was first used by the founder of the VPL Research firm, which was named Aaron Lanier, in the year 1987. SunMicrosystems later purchased the company in the year 1999. After that, Lanier formed a partnership with Zimmerman, who was the developer of the first data glove, and together they manufactured a broad variety of interface devices, including glasses, gloves, and head-mounted displays (HMD). The term "experience" was introduced by Mortein Heilig, who was the one who came up with the concept of virtual reality (VR). He did this by incorporating an oscillating fan into a 3D film so that the audience could experience the force of wind blowing on their face. Other pioneering computer scientists and engineers who contributed in some way to the term virtual reality include: Douglas Engelbart, who contributed to the participation of a user through mouse and keyboard; Ivan Sutherland, who is credited with creating the first head mounted display; and Myron Krueger, who is credited with computer graphics with audio in video projection of a user or person in a space, similar to the modern CAVE (Cave automatic virtual environment, but with no interaction).

1.2 Literature Review

Several researchers have highlighted virtual reality's adaptability to various design tasks, and they've emphasised the need to incorporate VR systems at every stage of the process, with the correct software and VR devices used at the relevant design stage (Adenauer et al.,2013; Weidlich, et al., 2009). Contrarily, some people were more concerned with narrowly targeting VR uses. Using virtual reality (VR) in the early stages of design has been highlighted by Cecil and Kanchanapiboon (Cecil, and Kanchanapiboon, 2007) and Camburn et al. (Camburn et al., 2017) as a means to increase product quality while reducing development time and costs. This is because VR makes it easier to uncover design flaws. As a result of the advent of VR interfaces connected to human interaction with virtual prototypes, Stark et al. (Stark et al., 2010) and Falcão and Soares (Falcão, and Soares, 2013) emphasised the practicality of VR systems for product evaluation. Virtual reality's utility for simulations was highlighted by Zignego and Gemelli (Zignego, and Gemelli, 2019), who cast doubt on the technology's ability to assess the product's aesthetics.Researchers in a few of the papers also thought about how realistic the virtual design environment could be by considering the level of immersion and how it may work with other technologies and tools. According to Stark (Stark et al., 2010), virtual reality (VR) has progressed to the point that it may evoke a sense of immersion in the user's senses, allowing for a more lifelike interaction and experience with a digital model. On the other hand, other academics saw this technology more as an auxiliary tool, since it couldn't provide a satisfactory level of immersion without including physical items and

haptic systems (Camburn et al., 2017; Petiot, and Furet, 2010; Wolfartsberger, 2019; . Zorriassatine, et al., 2003). Specifically, total manipulation control in the immersive (Virtual Experience) VE might be achieved by employing a real object as tactile feedback, since the sensation of touch is a key factor to consider when it comes to the VE (Panzoli, et al., 2019). From mentioned research above, there is still a lack of a holistic understanding of the benefits that virtual reality (VR) may bring to the design process. Without offering a broader perspective, many experts zeroed in on particular design functions. From a higher vantage point, we can examine the ways in which various design activities are aided by VR and the ways in which these functions can truly profit from the various degrees of immersion and supplementary tools. Several of the most recent assessments of VR technology in the literature have distinct aims or focused on different aspects of the technology (Patil et al. 2024a; Rane et al. 2024a; Patil et al. 2024b). While Rebelo et al. (Rebelo, et al., 2011) investigated virtual reality (VR) devices and the levels of immersion they offered, their analysis of VR systems' potential design applications was narrowly focused on user-centred design. The somewhat old work of Jimeno and Puerta (Jimeno, and Puerta, 2007) investigated virtual reality (VR) in conjunction with computer-aided design (CAD) and computer-aided manufacturing (CAM) in order to ascertain its significance, advantages, and advancements. In a similar vein, Berg and Vance (Berg, and Vance, 2017) focused on decision-making procedures to encourage innovation in the sector (Rane et al. 2024b; Rane 2024). Even though Kovar et al. (Kovar, et al., 2016) broadened the scope of the study to include additional design processes, it was only done in regard to virtual reality's role in Industry 4.0. The possibility of virtual reality in the design process was explored more thoroughly by Adenauer et al. (Adenauer et al.,2013). While previous articles often used produced virtual models as a way of evaluation, the inclusion of virtual prototyping in the early conceptual phases raises doubts. The examples of virtual reality (VR) used to help various design tasks shown by Coburnet al. (Coburn, et al., 2017) were limited in scope and did not pretend to be extensive.

1.3 Virtual Reality Experience

When someone is sat on a chair that is connected to a computer interface, they may experience virtual reality by travelling to Mars, the Moon, or any other location in the cosmos. They will feel as though they are travelling there and enjoying the atmosphere of the environment, surface, and surrounds, among other things, while they are experiencing this. One definition of virtual reality is that it is "an application that enhances the ability of a user or participant to perform navigation and interactivity with virtual objects in a virtual environment or situation in the real world." Does it have the same impact as sitting

in a chair in a theatre and watching a movie while experiencing the same degree of satisfaction as if he or she were the actor or actress being portrayed in the film? The addition of mobility (viewing and maybe sound, haptic, etc., he or she can move around along with the computer-interface) is what separates this scenario from a travel to Mars or the Moon or any other destination in the universe. Motion is something that is not present when watching a movie in a cinema, which is the normal event that takes place. This motion causes him or her to engage with the environment as if it were real, but in reality, it is not (for example, when viewing a movie while seated in a chair, there are no interactions that take place while watching the movie). When compared to the second scenario, which involves the typical and non-interactive viewing of a movie on a flat surface, the first scenario is interactive, meaning that the user's senses engage with the virtual environment that is generated. This immersive experience also encompasses the user at times. Because the name "virtual reality" is associated with a simulation or scenario of this kind, virtual reality is primarily comprised of two senses: sight and hearing. The primary objective of virtual reality is to give the user or participant the impression that they are experiencing something that, in fact, does not exist. A head-mounted display set, earphones for music and speakers, and a computer or smartphone are the interface devices that are taken into consideration in the first scenario. From a fundamental standpoint, the virtual reality world is limitless since the seamless brain is capable of imagining any circumstance that has never been seen before (given that such a simulation is entirely feasible). Interfacing devices like as Head Mounted Displays (HMDs), controllers, gloves, and other body components, among others, are responsible for tracking the location of objects in Euclidean space. Fig. 1.1. illustrates a VR system.

This information is then transmitted to the computer, where it is processed further and stored in databases so that the system can function. Additionally, the information that is recorded in the database takes the required reaction to stimuli (the feedback system) for the matching movement of the tracking device or the body parts (such as the hand, etc.) that are moved partially or completely by the user.

1.4 Characteristics of the virtual reality system

The properties of virtual reality may be broken down into the following categories: (I) Simulation (of as many senses as feasible); (II) A computer; (III) Interface devices; (IV) Presence/Telepresence; (V) Interactions/Interactivity; (VI) Experience; and (VII) Imagination; and (VIII) Immersion. (I) ***Simulation***; The idea of simulation, which entails the development of a scenario via the use of as many senses as feasible, is founded on the premise that anything that would exist in reality is that which is being made. Utilising any

or all of the five senses (sight, hearing, smell, touch, and taste) and commanding them to communicate sensory information to the human brain (via the neurones) is one method that might be utilised to accomplish this goal. To put it another way, the use of technology has the capacity to entirely disrupt the senses of sight (panoramic), sound (acoustics), haptics and feedback (tactical), smell (olfactory), and taste (gustation). (II) ***Computer***; The information flow is then made to flow as a stream of bits to the computer, which will then understand it and then action upon it using a human computer interface device. This process is repeated until the information flow is complete. The interface device is a mix of sensors, hardware, and software, and it is meant to read the signals that are arriving and going through it in order to interact with the user's brain in order to generate a sense of the simulated scenario as a whole. (III) ***The interface device*** is designed to produce a sensation of the simulated situation as a whole. The user can be physically present in close proximity to the computer that is being used from a remote place (presence/telepresence). This is accomplished through the use of telepresence technology. (IV) ***Presence/Telepresence***; The word "presence" refers to the fact that the user is physically present in the area in question and is connected with the virtual objects at the current time (which means that they are not physically present). In comparison, the virtual objects are not physically present. When this takes place, the user or participant has a sensation of alienation from the actual world as well as a sense of being lost in the virtual world. They have a strong connection with the virtual objects that are there in the virtual world, and they start to feel as though they are physically present in the virtual world as a result of the simulated sensory pathways in their brain. (V) ***Interaction/ Interactivity;*** The movements of the user through the sensory channel of digital impulses and the presence of virtual things in the real world (via the computer and the devices that connect with it) are both components of the interactions that take place. (VI) ***Experience;*** It is common practice to use the word "experience" when referring to such circumstances as this one. (VII) ***Imagination*** is also a component in this state, since the thoughts that come from the mind that appears to be devoid of any structure need to be mapped out in an innovative fashion within the context of the circumstance. This condition is characterised by the fact that the mind appears to be devoid of any structure. (VIII) ***Immersion;*** A person is said to be immersed in a digitally built sensory channel when they are placed in a position that is like to the one described above. This position requires them to remove oneself from the natural sensory channels and instead get immersed in the sensory channel that was created digitally.

Fig.1.1. A VR system

Michael Abrash, who worked at Valve in 2014, stated that presence must fulfil the following requirements: (i) a wide field of view (at least 80 degrees), (ii) an adequate resolution (1080 pixels or more), (iii) low pixel persistence, (iv) a high refresh rate (greater than 60 Hz), (v) a global display (every pixel must be illuminated), and optics (at least two lenses per eye are required). All of these requirements must be met within the presence of the device. In the event that this takes place with a user in real time, it is referred to as a personal experience of virtual reality. It is possible for the user to continually watch and exert control over all exchanges if they make use of the interfacing devices. In order to create such a simulation, it is required to have knowledge about the brain as well as the neuron-to-neuron communication gateway that is accessible through the computer interface. In order to create a simulation of this kind, it is necessary for computer scientists and engineers to possess this level of competence. Immersion may be defined as the number of a user's senses that have been stimulated to a particular level of interactivities with virtual things in real time in order to give the user the impression that it is truly occurring. This is done in order to give the user the idea that they are experiencing something that is actually happening. It is essential to have a low latency value that is bigger than or equal to twenty milliseconds (the amount of time that passes between the last motion and the photon). The following are some more technological features of virtual reality for consideration: (I) ***F.O.V. stands for field of view;*** It is estimated that the average human has a field of vision that is around 200 degrees. Headsets

are pleasant to wear provided that the temperature is between 90 and 110 degrees. An increase in the value of the field of vision results in an experience that is much more immersive. (II) ***Frames per second, often known as FPS***, is the rate at which individual image frames are updated in accordance with the passage of one second. Frames per second are the units of measurement for this rate. When the frame rate per second (FPS) number is increased, the motion becomes more fluid, which leads to an experience that is more enjoyable and immersive. It is recommended that the frame rate be greater than 90 frames per second per hertz in order to avoid creating feelings of nausea. The slower the action is, the lower the frame rate will be, and this will cause you to feel sick. (III) ***Motion-to-Photon Latency*** is a measurement that determines the amount of time that passes between the actual motion that is taking place in real time and the eye's perception of a photon that has been sent back from the head-mounted display screen. In the event that the value of motion-to-photon delay is increased, the phenomenon known as motion sickness will be triggered. This component deceives the senses into believing that the user is actually taking part in the virtual world. (IV) ***Motion tracking:*** This factor is responsible for this illusion. Positional tracking is another factor that contributes significantly to the immersive experience that virtual reality provides. In proportion to the degree of accuracy of the positional tracking, the user will have a greater sense of immersion in a virtual setting. (V) ***The Inertial Measurement Unit***, sometimes known as the IMU, is a piece of electrical equipment that is used to detect motion. An accelerometer, a gyroscope, and a compass are the components that make up an IMU. These components are used to measure the rotation of the device with a low latency value (for example, the Samsung Gear). Fig. 1.2. illustrates VR system components.

Fig.1.2. VR system components

(VI) ***Eye tracking:*** The cameras that are put within the head-mounted display (HMD) have the ability to monitor the movement of the user's eyes in order to determine the direction the user is looking. Increasing the value of the screen resolution results in an immersive experience that is both more clear and more lifelike. (VII) ***Synthesising the sound*** that is coming from a particular position in the virtual world is accomplished through the use of spatial audio, which is the nineteenth type of audio. This allows the user to hear the sound even while they move about in their environment. (VIII) ***Stereoscopy:*** The majority of stereoscopic phenomena include the presentation of two offset pictures that are two-dimensional to the user's left and right eyes in a distinct manner. After that, the brain combines them in order to create the impression of three-dimensional depth. By applying pressures, vibrations, or movements to the user, haptics and kinesthetics are able to assist in the recreation of the sensation of touch. This is accomplished through the use of feedback devices. For the purpose of measuring the forces that are applied by the user on the interface devices, the approach involves the use of tactile sensors.

Conclusions

Virtual reality (VR) enables users to experience games, cultures, and training in a three-dimensional realm by means of immersive surroundings. For instance, a student in high school may virtually dissect a frog, according to the explanation provided by teachers. Because of this, the learner is able to alter the topic without having to make a costly purchase for the laboratory. Virtual reality also extends beyond the realm of education and training at the elementary level. Virtual reality headsets equipped with controllers are being utilised by healthcare professionals for the purposes of patient education and therapy. For example, the use of virtual reality (VR) to soothe a patient who is worried can improve treatment for almost any condition.

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