Deep Science Publishing
https://doi.org/10.70593/978-81-982935-1-0_2

Chapter 2

The essential foundations of virtual reality

Dina Darwish

Artificial Intelligence Department, Ahram Canadian University, Giza, Egypt.

dina.g.darwish@gmail.com

Abstract: A virtual reality (VR) headset and a pair of portable controllers generate an artificial environment. We may find ourselves swept away to a game platform, a training movie, or an instructional activity in this immersive realm. To fully grasp the effects of virtual reality on various sectors, one must be familiar with its inner workings. We need to find out what VR is and how it creates a new universe by diving into the fundamentals. On the most basic level, virtual reality technology is donning a headgear with a high-resolution screen and positioning it as near to the eyes as feasible. Virtual reality (VR) developers create a 3D illusion by merging the screen with their own unique lenses. This chapter focusses on several topics including; how VR works, Types of VR Technology, Components of VR system, how VR provides immersive experience, Applications of VR, Advantages and disadvantages of VR, and Future perspectives of VR.

Keywords: Types of VR Technology, Components of VR system, Immersive experience, Applications of VR, Future perspectives of VR.

Citation: Darwish, D. (2025). The essential foundations of virtual reality. In *Virtual Reality Technologies and Real Life Applications* (pp. 14-33). Deep Science Publishing. https://doi.org/10.70593/978-81-982935-1-0_2

2.1 How Virtual Reality Works

In order to create a digital world, virtual reality (VR) involves the use of many technologies, such as a head-mounted display (HMD), a motion-tracking sensor, and a smartphone, computer, or any other device. The content is displayed to the user through the use of head-mounted displays (HMDs). Using an HDMI cable, the material is transported from the personal computer to the screen. Smartphones are used in virtual reality (VR) devices such as GearVR and Google Cardboard. These smartphones serve as both a display and the source of the content. VR equipment are capable of achieving a field of sight of 110 degrees at 60 frames per second, and the use of lenses transforms two-dimensional pictures into three-dimensional ones, which makes simulations appear to be genuine. There are a few different alternatives available for user interaction: X, Y, and Z axes are assigned to directions and motions in order to follow the movements of your head to the sides and angles. This is referred to as head-tracking. ***Eye-tracking*** is a technique that uses an infrared controller to monitor the movement of the eye. ***The tracking of motion;*** Motion tracking is separated into two categories: optical and non-optical, based on the utilisation of six degrees of freedom (DoF) and three-dimensional space. Non-optical motion tracking is accomplished by the use of sensors, whereas optical motion tracking is accomplished through the use of a camera.

Hardware; In order to give the user the impression that they are immersed in the experience, a substantial quantity of both hardware and software is required. Through the use of various input devices, it makes it possible for the user to interact with the virtual world. The following are some examples of things that might fall under this category: controller wands, joysticks, data gloves, on-device control buttons, motion trackers, bodysuits, and motion platforms. Gyroscopes and motion sensors are used for determining the positions of the head, body, and hands; motion controllers; optical tracking sensors; the three-dimensional mouse; and the wired glove are all examples of these types of devices. The output devices, which are devices that stimulate a sense organ, are the ones responsible for the creation of the virtual reality surroundings. Displays that are either visual, auditory, or tactile, headphones, and speakers are a few examples of these types of devices. virtual reality headsets equipped with omnidirectional cameras, head-mounted displays, stereoscopic displays made up of small high-definition screens, and the CAVE haptics and sensor technologies are all examples of technologies that might be used. Fig 2.1. illustartes VR system parts.

2.2 Types of Virtual Reality Technology

The following are many types of virtual reality technology: (I) Non- immersive VR (II) Fully immersive VR (III) Augmented Reality (AR) (IV) Collaborative or Disruptive VR; stands for collaborative and distributive, (V) Web-based VR; some instances of these kinds of technologies are those that are web-based. (I) ***Non-immersive*** virtual reality, which is also frequently referred to as desktop virtual reality, is a kind of virtual reality that also goes by the name of desktop virtual reality. The individual who is participating in this kind of virtual reality is not completely submerged in any kind of virtual world. At the same time that they are aware of the sensory channels, which are mostly constituted of sight, hearing, and haptics, the participant is able to keep control over the physical environment that is all around them. Activities that are not considered to be immersive include, for instance, the creation of a three-dimensional model of a building via the use of a computer-aided design (CAD) software or the simple act of watching a movie. One example of a virtual reality experience that is semi-immersive is a flight simulator that is used for the purpose of educating pilots who do not have any prior experience in the field. (II) ***Fully immersive*** simulations are used to train pilots of combat planes or astronauts heading into spacecraft. These simulations are used to instruct pilots. The training of pilots is being done with these simulators.

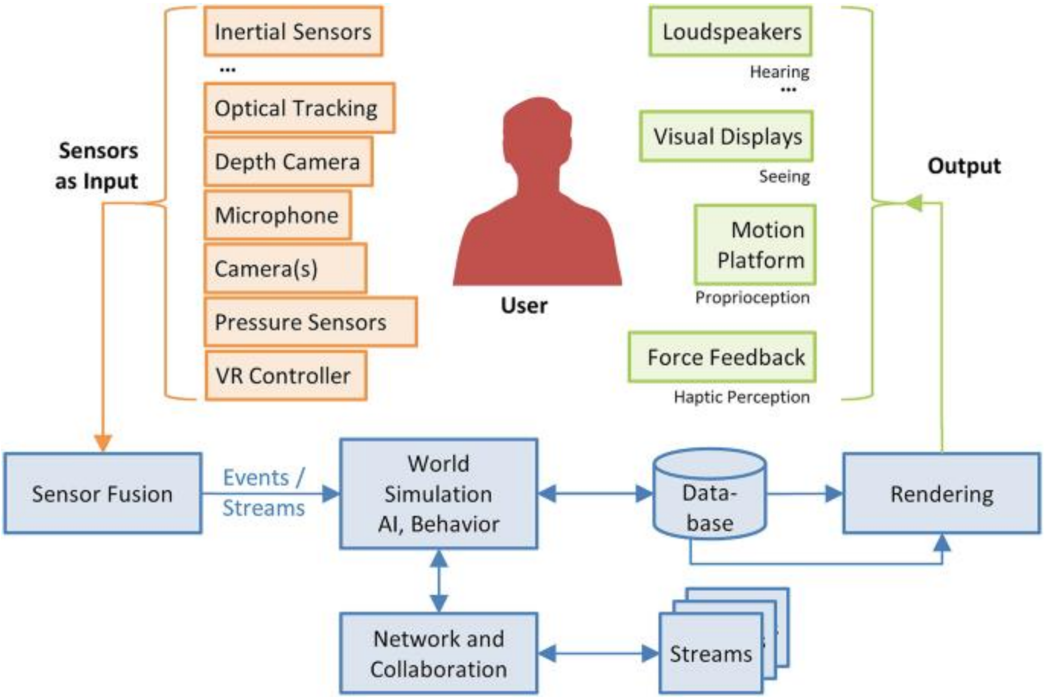

Fig. 2.1. VR system parts

Utilising the head-mounted display (HMD) and the sensory hand gloves, the user is put into a state of total immersion during the second entirely immersive simulation. This allows the user to feel absolutely immersed in the experience. When wearing these gloves, the wearer is able to perceive not just sight and sound but also movement inside a particular environment or situation. Both the head-mounted display (HMD) and the sensory hand gloves are employed for this purpose. A professor at a university and a consultant in game design, Ernest W. Adams, has identified three separate types of immersion: (i) Tactical immersion, (ii) Strategic immersion, and (iii) Narrative immersion. Every one of these types of immersion is distinct from the others. (i) ***Tactical immersion;*** being able to do tactile operations that demand a high level of competence is one way to produce a sort of experience known as tactical immersion. ii) ***Strategic***

immersion is a form of experience that is related with a great degree of planning, analytical, and thinking concepts (similar to how a game of chess requires a lot of preparation and thought). (iii) ***Narrative immersion*** is a form of experience in which the user or participant assumes a position in a tale (examples of which include a movie, a novel or story, etc.). (III) ***Augmented Reality***; Tom Caudell, a researcher at Boeing, is credited with being the first person to present the concept of augmented reality in the year 1990. On the other hand, it had been around since the beginning of the twentieth century, but nobody had been aware of its presence until recently. This is a philosophical approach in which a depiction of a virtual world is superimposed on top of the real-world surroundings. It is common practise to use mobile phones, Google Glass, and other gadgets that are functionally equivalent as interface devices. Some instances of augmented reality include the ability to play video games in the actual world, the ability to educate pupils, and the ability to witness a spaceship land in a nearby field or region where he or she lives (this was portrayed in the Hindi Bollywood movie Koi Mil Gaya (2003) and PK (2014), among other examples). (IV) ***Collaborative or Distributive virtual reality*** offers the user a form of interactive experience in which the user may collaborate with other individuals who are physically present in the same virtual world. (V) ***Web-based VR***; Computer scientists and engineers are responsible for the programming in virtual markup language (VMRL) that is used in order to develop web-based virtual reality experiences that are available over the internet. Fig .2.2 illustrates types of VR Technologies.

Virtual reality applications that are based on the web have a great deal of promise when it comes to activities such as browsing the internet, buying, and socialising (Patil et al. 2024a; Rane et al. 2024a; Patil et al. 2024b). On social networking websites, users engage with one another in order to take use of the platform's benefits, which might lead to the creation of collaborative work (Rane et al. 2024b; Rane 2024). During the process of developing patterns for video games, Staffan Bjook and Jussi Holopainen defined the following types of immersion: (i) sensory-motoric immersion; (ii) emotional immersion; (iii) cognitive immersion; and (iv) spatial immersion. Each of these types of immersion is described differently. The following is a list of other factors that have an effect on the immersive digital simulation: A number of factors, including but not limited to: (i) believable three-dimensional computer graphics; (ii) user input and output responses; (iii) simplicity; (iv) functionality; (v) the potential for enjoyment; (vi) effects of wind and seat vibration; and (vii) lighting.

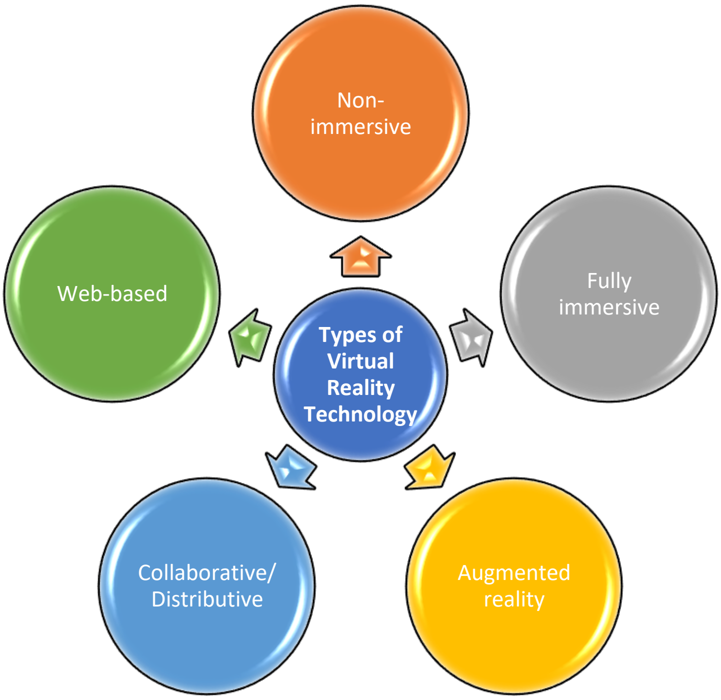

Fig.2.2. Types of VR Technologies

2.3 Constituents of the Virtual Reality System

How does virtual reality function with the most recent products? A virtual reality headset with controllers that is highly regarded, such as the PICO 4 headset, incorporates cutting-edge technology that brings virtual reality environments to true life. Now, let's dissect the virtual reality components that made it possible to create these unique worlds.

(I) Virtual reality headset

The headgear is the most important part of any virtual reality system. What is the operation of virtual reality headsets? Every design, regardless of the brand, must have a screen that is totally enclosed and covers the eyes throughout the entire design. By providing a comfortable strap that wraps around the head as a counterweight, these headsets allow you to completely submerge yourself in an experience that is completely distinct from the world that is actually going on around you.

(II) PC VR

Over the past ten years, virtual reality headset manufacturers have placed a significant emphasis on personal computer virtual reality headsets. Notable early releases such as the Oculus Rift and HTC Vive have contributed to the development of the industry as it exists today. Examples of contemporary products include the Pimax 5K Super, the HP Reverb G2, and the Valve Index. These headsets typically have the most visually appealing displays, in addition to supporting the highest quality visuals, having the highest refresh rates, and having the best library of games available across the Meta store and SteamVR platforms. They are available with a variety of controller options, can be wired or wireless, can use either inside-out or external tracking, and can use either method. On the other hand, they are almost always the most expensive virtual reality headsets, and in order to use them, you need a gaming computer that is both powerful and expensive.

(III) Console Virtual Reality

Although there haven't been a lot of virtual reality headsets for consoles, the PlayStation VR (PSVR) and PlayStation VR2 (PSVR2) are two options that are capable of doing exactly that and have proven to be extremely popular. Although they do not have all of the capabilities that are available on the best PCVR headsets, they have been competitive since their release. Compared to PCVR solutions, they are typically more affordable; however, they are not inexpensive and require either a PlayStation 4 or a PlayStation 5 in order to function.

Virtual reality headsets that are powered by their own internal processing, inside-out tracking, a battery, and wireless motion controllers are referred to as standalone virtual reality headsets. Virtual reality headsets are arguably the most accessible way to experience virtual reality because they are designed to include everything that is necessary to get started with virtual reality technologies. However, they have a limited battery life, and their internal graphics processors are not even close to being able to compete with what console and personal computer virtual reality can offer. Having said that, they are significantly more affordable, particularly when you take into account the fact that you do not require an external console or personal computer to power it.

(IV) Screens and focal lenses

There is a complicated assembly that fits inside of a headset. This assembly consists of a screen and many lenses. In point of fact, the screen represents the beginning of the visual experience that you will have when you activate the system. It is preferable that the screen ought to have a resolution that is documented for both eyes.

On the other hand, the headset may be equipped with one or more lenses that produce a three-dimensional effect. Virtual reality (VR) manufacturers like PICO 4 use pancake lenses, which are lightweight assemblies that contain multiple lenses in a single package. The virtual reality world is sharp and responsive when coupled with a high-quality screen and pancake lenses.

(V) Field of View and Latency Indicators

How does virtual reality function? To appear realistic, it must be able to follow the motions of the user. To do this, it is vital to have a low latency or delay in order to stimulate immersion. Additionally, the field of view, also known as FOV, is the perspective that is achieved through the use of a headset. As an illustration, PICO 4 headsets have a field of view (FOV) of 105 degrees, which is more than normal vision, which has approximately 200 degrees of visual references.

(VI) Rate of frames

When referring to a system, the term "frame rate" refers to the rate at which the CPU can generate new visuals for the user. In an ideal scenario, a high frame rate will keep you completely submerged in the setting.

(VII) Spatial Audio in Three Dimensions

For the sake of realism, virtual reality (VR) must respond in the same manner as humans, who perceive sounds in almost every direction. As a consequence of this, 3D spatial audio is able to simulate real life with higher-end speakers.

(VIII) The tracking of the head and location

Virtual reality headsets that come with controllers typically include depth-sensing cameras, accelerometers, and gyroscopes. These components are designed to monitor the position of the user's head. Moving your head causes these components to make adjustments to the audio and video in order to produce an experience that is logically consistent.

(IX) Various motion controllers for virtual reality

The majority of the virtual reality experience takes place at eye level; nonetheless, your immersion would not be complete if you did not use your hands with the technology. Virtual reality motion controllers are typically considered to be gadgets that are held in both hands. Examples of what you can do with these gadgets include pointing, gesturing, grabbing, and shooting.

In addition, these controllers offer the system an additional sensory input with which it can interact. A visual representation of this action will appear on the headset whenever you raise your hands using the controllers. When you have controllers that are wirelessly attached to your headset, you will have a variety of powers, including the ability to shoot accurately.

Table 2.1. provides a summary of the primary technologies that were taken into consideration and identified as macro categories (Backhaus, et al., 2014; Rentzos, et al., 2014; Villagrasa, et al., 2014; Marks, et al., 2014; Grajewski, et al., 2015; Bharathi, and Tucker, 2015; Rojas et al., 2015; Zhang, et al., 2015; Rieuf, et al., 2015; Freeman, et al., 2016; Górski, et al., 2016; Rieuf, et al., 2017; Wolfartsberger, et al., 2017; Valencia-Romero, and Lugo, 2017; Berg, and Vance, 2017; Eroglu, et al., 2018; Guo, et al., 2018; Song, et al., 2018; Rogers, et al., 2018; Elbert, et al., 2019; Kato, et al., 2019; Jayasekera, and Xu, 2019; Riegler, et al., 2019; Violante et al., 2019; De Crescenzio, et al., 2019; Guo, et al., 2020; Lukačević et al., 2020). Accompanying each of these technologies is a description of the devices that can be attributed to the reference technologies included in the table. The virtual reality (VR) technology that was utilized in certain contributions was not possible to be inferred (an unidentified VR system), and additional devices have been identified that cannot be included within the context of the mentioned reference technologies.

Numerous studies combined visualization hardware with interaction hardware, enabling participants to engage with and alter the model within the virtual environment. As previously indicated, these integrated devices are considered essential for the efficacy of VR in design, as emphasized in several contributions (Camburn, et al., 2017; .Petiot, and Furet, 2010; Wolfartsberger, 2019; Panzoli,et al., 2019). We categorized the supporting tools according to the senses engaged and the degree of engagement offered. The sense of touch can be elicited through several methods; nevertheless, while interactive gloves allow users to engage with the virtual model in a more intuitive manner, haptic devices facilitate a more deliberate and accurate contact with the same model. A particular category of auxiliary tools comprises biometric devices, which are progressively utilized in design research (Borgianni, and Maccioni, 2020). While they do not promote immersiveness and involvement in virtual reality, the latter is observed through unintentional human emotions and behaviors; hence, investigations utilizing virtual reality may yield more valuable data. Table 2.2. delineates the primary categories of supporting tools and provides representative devices for each classification. Fig 2.3. shows a VR headset components.

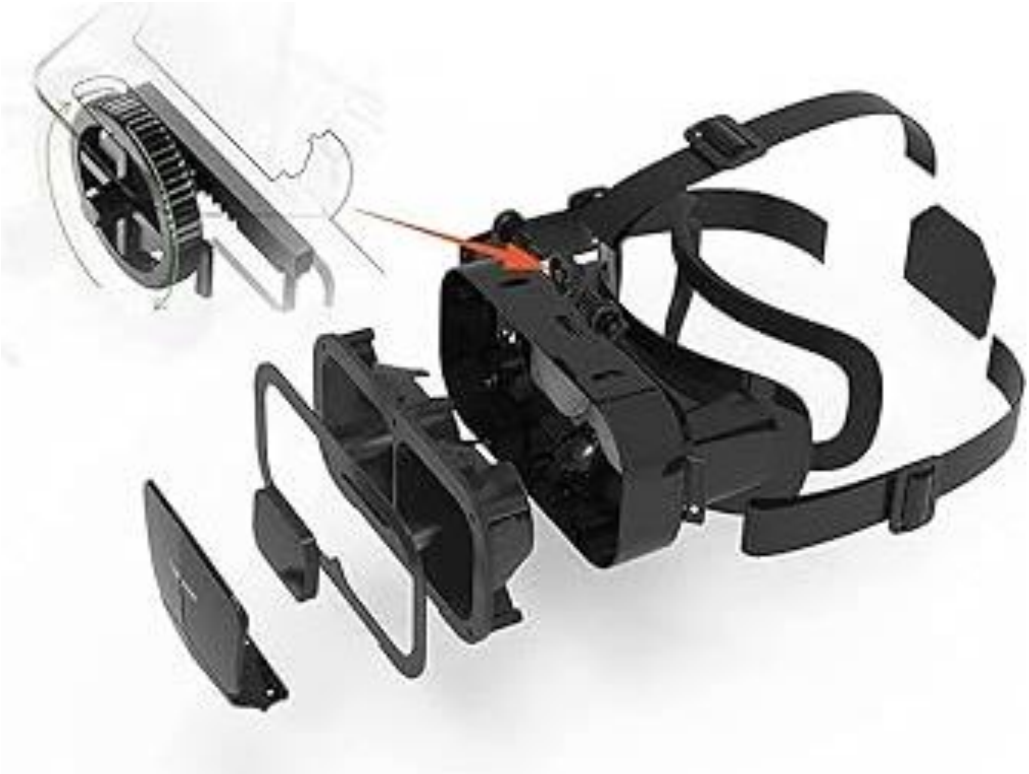

Fig.2.3. A VR headset components

Table 2.1. Categories of VR technologies involved.

Technology used for visualization	Devices
Head-mounted displays (HMD)	Oculus Rift, HTC Vive (Headset + controllers) or similar, TiciPrep/TiciView (Headset), Microsoft™ Hololens™
CAVE or similar	CAVE system and other technologies which involve a large field of view and 3D glasses for visualization, Cyviz (rear-projected wall display)
Desktop VR with stereo glasses	Desktop VR with stereoscopic glasses for a three-dimensional view
Unspecified VR system	Unknown/ unspecified VR system and adopted devices for mixed reality mock-ups
Other	OpenRT (Open Ray-Trace) techniques, AutoEval interface, two stereo, VirDe, stereoscopic screen

	with collocated motion parallax which renders the visual experience logical and realistic, V.R.A.D.U., WorldViz VR devices, Photographed VRs, Ramsis system, SATIN system

Table 2.2. Categories of VR supporting tools for interaction with a 3D model in the virtual environment.

Supporting tools	Devices
Supporting tools for interaction	HTC Vive hands controllers, FlyStick (a 3D pen), Virtual pencil, Wii remote, pliers tool, two-handed Bezier tool, stylus, wand
Interaction gloves	CyberGlove, Pinch gloves, Mattel PowerGlove TM, Immersion CyberTouch
Sound inputs and/or outputs	Voice recognition, audio output, stereo speakers
Haptic systems (haptics)	Phantom haptic force devices, free force haptic systems, tactile feedback, haptic feedbacks in general, 3D mouse, Spaceball mouse, real objects (e.g., chairs or steering wheels, pedals, vibrating elements in driver's seat), VirtuoseTM6D35-45 haptic device
Motion tracking devices	Head motion tracker/hand motion tracker, head-repositioning device, leap motion
Traditional control devices	Keyboard, mouse, joysticks, gamepads, touch screens
Biometric instruments	Eye Tracking, Galvanic Skin Response, OptiTrack optical tracking system
None/unspecified	No supporter device was used
Other	Projector, spherical mirrors, spherical screen, digital tablet, and drawing support

2.4 The Ways in Which Virtual Reality Can Offer an Immersive Experience to Users

What is the operation of virtual reality headsets? The first thing that they do is build a visual environment that encompasses the entire field of view of the visitor. There is also a dynamic quality to these pictures. As a result of the fact that users will instinctively glance in all directions when confronted with a novel environment, these graphics will alter based on the rotation patterns of the head. The environment is made to appear more lifelike with the use of software sensors that mislead the sight.

There are a variety of products that, depending on the headset, use gadgets that track the eyes of the user. In essence, the program is able to determine the potential location of the focus by analysing the micromovements that are produced by the eyes. The user's actions are properly matched to the game's environment, which results in the sensory input appearing and feeling as though it were genuine. Ultimately, the likelihood of experiencing motion sickness is decreased while using items and games of a high quality.

After that, the software will manipulate your hearing by presenting you with noises that originate from particular directions. Take, for instance, the scenario in which you hear an explosion in your right ear, which prompts you to move your head in that direction. There is a possibility that bullets that are ricocheting nearby will divert your attention elsewhere.

Touch has been incorporated into your immersive experience in order to complete this sensory input. Maintain control of those controls since you might be in the middle of a gunfight, a fistfight, or some other kind of dispute in the near future. Because the human mind is dependent on these sensory inputs, a virtual reality headset that comes with controllers can be extremely useful for a variety of purposes, including gaming, training, and other activities.

2.5 Applications of Virtual Reality

Numerous fields, including the military, healthcare, education, scientific visualisation, and entertainment, can benefit from the utilisation of virtual reality. However, these are not the only options available. The sector is expanding at a rapid rate, and more, more advanced applications that make use of more sophisticated technology are making their way to the market. For virtual reality (VR) based goods, there is a demand in the market. Nevertheless, there are a few philosophical, privacy, and health problems that are associated with virtual reality.

Applications in the following fields: (I) ***Education:*** Virtual labs are being built via the use of ICT (Information and Communication Technology) technologies that provide learners with the opportunity to experience a lab environment on their desktop computers, mobile phones, or laptops. No fees are required to use virtual laboratories. The system is a learning management system that caters to all different kinds of learners in a wide range of academic fields, taking into account the learners' individual interests. All of the relevant resources, including learning materials, a pre-test, and a post-test, are provided in a single location. It offers virtual or remote kind lab experiences, depending on the user's preference. Instead of learning in actual labs, where they might lose interest or sometimes risk the possibility of getting hurt, such as when they are performing a real lab experiment in a chemistry lab (for example, a reaction of concentrated acid, etc.), the learners are able to learn at their own pace, further motivating themselves towards their interests. At the school level, at the undergraduate level, at the graduate level, and throughout the post-graduate level of education, this is good for all sorts of learners. During this period of COVID-19 lockdown, which has been going throughout the world, virtual labs are allowing hundreds upon thousands of students to learn their lab tests through the use of virtual laboratories. Since January 2020, and in the midst of the lockdown caused by the COVID-19 epidemic, a significant number of students attending universities and colleges worldwide have turned to virtual laboratories. For example, since the beginning of the year 2020 (IIITH), the International Institute of Information Technology in Hyderabad has enrolled more than one hundred thousand students to participate in virtual laboratories. The National Institute of Technology in Surathkal, Karnataka, has seen an increase in the number of students enrolling for remote-based experiments and remote-triggered laboratories (virtual labs) in this period. The total number of students registered is very huge. It has been claimed that the Indian Institute of Technology, Guwahati, located in the state of Assam, has enrolled more a big number of students for remote-based investigations in virtual laboratories during this pandemic lockdown, which is related to the COVID-19 virus. (II) ***The Judicial Branch***: Due to the recent COVID-19 pandemic and the subsequent prolonged lockdown (which began on March 25, 2020), the subordinate judiciary judges in Delhi have been required to undergo training to handle trials in a virtual arena rather than in a physical courtroom. This is done in order to gain expertise dealing with cases in a virtual courtroom. Over this period, many training judges have received instruction on how to carry out processes in the courtroom. This instruction has been provided through a variety of means, including videoconferencing, simulated trials, and other techniques. These trainee judges have been proved to profit more from this sort of virtual reality experience, which has shown to be an effective technique of training them. This is because they are able to conduct the trials without having to physically attend to a courtroom. The learners may have experienced the training program as if it were a movie that was being played in real time in the digital space. (III) ***Films:*** Virtual reality (VR) experiences are being utilised in films (popular science fiction blockbusters from Hollywood such as The Matrix, and the Hindi Bollywood film Krrish and its sequel, among others) to create an immersive environment for the spectator. For the purpose of allowing people to create and experience the narration of the tale in a more profound and impactful manner, the approach of interactivity is utilised there. Among the films that fall within this category is Carne y Arena. (IV) ***Games:*** internet games ranging from basic to multiplayer, in-flight and other driving simulations, and so forth. To provide an example, Facebook has developed a feature called Spaces, which allows users of the Oculus Rift to enter a virtual place that they have shared with other people. Fig 2.4. illustrates VR headset receiving data, Fig 2.5. illustrates students wearing headsets in the classroom, and Fig 2.6. illustrates analysing objects with VR headset.

Fig.2.4. VR headset receiving data

(V) ***In Medical science issues***: this experience takes smokers on a tour around their mouth, lungs, heart, and other organs, allowing them to see and feel the harm that smoking does to their bodily systems. In addition, it has been utilised in the treatment of patients suffering from schizophrenia, pain-related conditions, surgical procedures, postural balance and motor functioning, therapeutic applications, and so on. (VI) ***Architecture designs***: It is utilised by architects in the design of buildings, analysis (finite element analysis), navigation, evaluation, computer-aided design (CAD), operations, and Internet of Things devices installed, among other applications.

Fig.2.5. Students wearing headsets in the classroom

Fig.2.6. Analysing objects with VR headset

From the previous applications, it is possible to view videos and films in 360 degrees, as well as experience the creation of virtual things. Additionally, users had the ability to emote by expressing themselves through facial expressions for their virtual avatars to execute. Even the avatars were designed to be able to shoot selfies in the virtual world. VR is finding a number of applications in the field of medical science, particularly in the creation of virtual tours of the organs that are found in human bodies. For instance, Bioflight VR is one of these companies that provides an experience that is tailored exclusively for smokers who have attempted to stop smoking.

2.6 Advantages and Disadvantages of Virtual Reality

The advantages of virtual reality Virtual reality, which offers users 360 degrees of freedom, has been shown to have effective functions of attention and memory, according to study conducted between two groups of people who have healthy memories. Virtual reality exposure therapy (VRET) is a treatment that is utilised in the realm of medical sciences with the purpose of treating individuals who are experiencing acute pain. It has also been discovered that augmented reality exposure based treatment, commonly known as ARET, is more useful than virtual reality exposure therapy (VRET). VR has a number of drawbacks, including the following: (i) ***Simulation and cyber sickness***, which occurs when the user is stationary but has a sensation of motion that is created by the exposure to shifting visual images; (ii) ***Motion sickness***, which occurs when the user is exposed to rotating motions; and (iii) S***tress, addiction, loneliness***, depression, and other negative emotions, which are caused by immersive virtual reality. (iv) ***System factors*** (the configuration of the entire system), individual user factors, application design factors (software), and virtual reality headsets are all elements that cause eye strain. On the basis of the superimposition of virtual elements in the actual environment and interactions, augmented reality has been divided into several categories, such as; (i) Based augmented reality (AR) places an emphasis on the recognition of objects; (ii) Location based augmented reality (AR) uses the global positioning system (GPS), digital compass, and accelerator as data providers based on location; (iv) Outlining augmented reality (AR) is also based on object recognition; (v) Superimposition based augmented reality (AR) offers an alternative option to replace an entire or partial view of an object with an augmented view. As a consequence of increased research and technological advancements, as well as a rise in the utilisation of input and output devices, there will be a greater variety of augmented reality (AR) options accessible in the future.

2.7 Future Perspectives of Virtual Reality

Virtual reality will make use of an increasing number of input devices as time continues to move forward. Through the use of body suits and whole body to finger tracking, for instance, a user will be able to experience virtual reality in a natural and realistic manner. The users will be able to engage with the virtual environment as if they were in a real-world scenario by reaching out with their hands and doing so simultaneously. Virtual reality (VR) may have the chance to grow in the future when quantum computers are used, however this will depend on the techniques and technologies that are used. Virtual reality (VR) technology is seeing a quite rapid expansion. Over the next several years, investments in virtual reality and augmented reality will multiply several times. Fig 2.7. illustrates future applications of VR.

Fig.2.7. Future applications of VR

Conclusions

Virtual reality (VR) has a significant potential for expansion in the future. In light of the past COVID-19 epidemic, virtual reality technology is currently being utilised on a worldwide scale in many fields; such as, medical science, training and entertainment, as well as in various levels of government functioning, among other applications. As part of the past worldwide COVID-19 epidemic, virtual reality (VR) is also being utilised in education departments at all levels, in topics pertaining to the court, and other areas.

References

Backhaus, K.; Jasper, J.; Westhoff, K.; Gausemeier, J.; Grafe, M.; and Stöcklein, J. (2014). Virtual Reality Based Conjoint Analysis for Early Customer Integration in Industrial Product Development. Procedia CIRP, 25, 61–68, doi:10.1016/j.procir.2014.10.011.

Berg, L.P.; Vance, J.M. An Industry Case Study: Investigating Early Design Decision Making in Virtual Reality. J. Comput. Inf. Sci. Eng. 2017, 17. doi:10.1115/1.4034267.

Bharathi, A.K.B.G.; Tucker, C.S. Investigating the Impact of Interactive Immersive Virtual Reality Environments in Enhancing Task Performance in Online Engineering Design Activities. Am. Soc. Mech. Eng. Digit. Collect. 2015, 57106, V003T04A004.

Borgianni, Y.; and Maccioni, L. (2020). Review of the use of neurophysiological and biometric measures in experimental design research. AI EDAM, 1–38. doi:10.1017/S0890060420000062.

Camburn, B.; Viswanathan, V.; Linsey, J.; Anderson, D.; Jensen, D.; Crawford, R.; Otto, K.; and Wood, K. (2017). Design prototyping methods: state of the art in strategies, techniques, and guidelines. Des. Sci., 3, e13. doi:10.1017/dsj.2017.10.

De Crescenzio, F.; Bagassi, S.; Asfaux, S.; Lawson, N. Human centred design and evaluation of cabin interiors for business jet aircraft in virtual reality. Int. J. Interact. Des. Manuf. 2019, 13, 761–772. doi:10.1007/s12008-019-00565-8.

Elbert, R.; Knigge, J.-K.; Makhlouf, R.; Sarnow, T. Experimental study on user rating of virtual reality applications in manual order picking. IFAC-PapersOnLine 2019, 52, 719–724, doi:10.1016/j.ifacol.2019.11.200.

Eroglu, S.; Gebhardt, S.; Schmitz, P.; Rausch, D.; Kuhlen, T.W. Fluid Sketching—Immersive Sketching Based on Fluid Flow. In Proceedings of the 2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), Reutlingen, Germany, 18–22 March 2018; pp. 475–482.

Freeman, I.J.; Salmon, J.L.; Coburn, J.Q. CAD Integration in Virtual Reality Design Reviews for Improved Engineering Model Interaction. Am. Soc. Mech. Eng. Digit. Collect. 2016, 50657, V011T15A006

Górski, F.; Buń, P.; Wichniarek, R.; Zawadzki, P.; Hamrol, A. Design and Implementation of a Complex Virtual Reality System for Product Design with Active Participation of End User. In Advances in Human Factors, Software, and Systems Engineering; Górski, F., Buń, P., Wichniarek, R., Zawadzki, P., Hamrol A., Eds.; Springer International Publishing: Cham, Switzerland, 2016; pp. 31–43.

Grajewski, D.; Diakun, J.; Wichniarek, R.; Dostatni, E.; Buń, P.; Górski, F.; Karwasz, A. Improving the Skills and Knowledge of Future Designers in the Field of Ecodesign Using Virtual Reality Technologies. Procedia Comput. Sci. 2015, 75, 348–358. doi:10.1016/j.procs.2015.12.257.

Guo, Z.; Zhou, D.; Chen, J.; Geng, J.; Lv, C.; Zeng, S. Using virtual reality to support the product's maintainability design: Immersive maintainability verification and evaluation system. Comput. Indust. 2018, 101, 41–50, doi:10.1016/j.compind.2018.06.007.

Guo, Z.; Zhou, D.; Zhou, Q.; Mei, S.; Zeng, S.; Yu, D.; Chen, J. A hybrid method for evaluation of maintainability towards a design process using virtual reality. Comput. Indust. Eng. 2020, 140, 106227. doi:10.1016/j.cie.2019.106227.

Jayasekera, R.D.M.D.; Xu, X. Assembly validation in virtual reality—A demonstrative case. Int. J. Adv. Manuf. Technol. 2019, 105, 3579–3592. doi:10.1007/s00170-019-03795-y.

Kato, T. Verification of perception difference between actual space and VR space in car design. Int. J. Interact. Des. Manuf. 2019, 13, 1233–1244. doi:10.1007/s12008-019-00568-5.

Lukačević, F.; Škec, S.; Törlind, P.; Štorga, M. Identifying subassemblies and understanding their functions during a design review in immersive and non-immersive virtual environments. Front. Eng. Manag. 2020. doi:10.1007/s42524-020-0099-z.

Marks, S.; Estevez, J.E.; Connor, A.M. Towards the Holodeck: Fully Immersive Virtual Reality Visualisation of Scientific and Engineering Data. In Proceedings of the Proceedings of the 29th International Conference on Image and Vision Computing New Zealand, Hamilton, New Zealand, 19–21 November 2014; Association for Computing Machinery: Hamilton, New Zealand, 2014; pp. 42–47.

Panzoli, D.; Royeres, P.; and Fedou, M. (2019). Hand-based interactions in Virtual Reality: No better feeling than the real thing! In Proceedings of the 2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games), Vienna, Austria, pp. 1–2.

Patil, D., Rane, N. L., & Rane, J. (2024a). The Future Impact of ChatGPT on Several Business Sectors. Deep Science Publishing. https://doi.org/10.70593/978-81-981367-8-7

Patil, D., Rane, N. L., Desai, P., & Rane, J. (Eds.). (2024b). Trustworthy Artificial Intelligence in Industry and Society. Deep Science Publishing. https://doi.org/10.70593/978-81-981367-4-9

Petiot, J.-F.; and Furet, B. (2010). Product, process and industrial system: innovative research tracks. Int. J. Interact. Des. Manuf. , 4, 211–213. doi:10.1007/s12008-010-0111-7.

Rane, J., Kaya, Ömer, Mallick, S. K., & Rane, N. L. (2024a). Generative Artificial Intelligence in Agriculture, Education, and Business. Deep Science Publishing. https://doi.org/10.70593/978-81-981271-7-4

Rane, J., Mallick, S. K., Kaya, Ömer, & Rane, N. L. (2024b). Future Research Opportunities for Artificial Intelligence in Industry 4.0 and 5.0. Deep Science Publishing. https://doi.org/10.70593/978-81-981271-0-5

Rane, N. L. (Ed.). (2024). Artificial Intelligence and Industry in Society 5.0. Deep Science Publishing. https://doi.org/10.70593/978-81-981271-1-2

Rentzos, L.; Vourtsis, C.; Mavrikios, D.; Chryssolouris, G. Using VR for Complex Product Design. In Virtual, Augmented and Mixed Reality. Applications of Virtual and Augmented Reality; Shumaker, R., Lackey, S., Eds.; Springer International Publishing: Cham, Switzerland, 2014; pp. 455–464.

Riegler, A.; Riener, A.; Holzmann, C. AutoWSD: Virtual Reality Automated Driving Simulator for Rapid HCI Prototyping. In Proceedings of the MuC'19: Mensch-und-Computer, Hamburg, Germany, 8–11 September 2019; pp. 853–857.

Rieuf, V.; Bouchard, C.; Aoussat, A. Immersive moodboards, a comparative study of industrial design inspiration material. J. Des. Res. 2015, 13, 78. doi:10.1504/JDR.2015.067233.

Rieuf, V.; Bouchard, C.; Meyrueis, V.; Omhover, J.-F. Emotional activity in early immersive design: Sketches and moodboards in virtual reality. Des. Stud. 2017, 48, 43–75. doi:10.1016/j.destud.2016.11.001.

Rogers, J.; Lo, T.T.; Schnabel, M.A. Digital Culture: An Interconnective Design Methodology Ecosystem. In Proceedings of the 23rd International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA): Learning, Adapting and Prototyping, Beijing, China, 1 May 2018; Volume 1, pp. 493–502.

Rojas, J.-C.; Contero, M.; Bartomeu, N.; Guixeres, J. Using Combined Bipolar Semantic Scales and Eye Tracking Metrics to Compare Consumer Perception of Real and Virtual

Bottles: Semantic Scales and Eye Tracking Metrics to Compare Perception. Packag. Technol. Sci. 2015, 28, 1047–1056. doi:10.1002/pts.2178.
Song, H.; Chen, F.; Peng, Q.; Zhang, J.; Gu, P. Improvement of user experience using virtual reality in open architecture product design. Proc. Inst. Mech. Eng. Part B J. Eng. Manuf. 2018, 232, 2264–2275, doi:10.1177/0954405417711736.
Valencia-Romero, A.; Lugo, J.E. An immersive virtual discrete choice experiment for elicitation of product aesthetics using Gestalt principles. Des. Sci. 2017, 3, e11. oi:10.1017/dsj.2017.12.
Villagrasa, S.; Fonseca, D.; Durán, J. Teaching case: applying gamification techniques and virtual reality for learning building engineering 3D arts. In Proceedings of the TEEM '14: 2nd International Conference on Technological Ecosystems for Enhancing Multiculturality, Salamanca, Spain, 1–3 October 2014; pp. 171
Violante, M.G.; Vezzetti, E.; Piazzolla, P. How to design a virtual reality experience that impacts the consumer engagement: the case of the virtual supermarket. Int. J. Interact. Des. Manuf. 2019, 13, 243–262. doi:10.1007/s12008-018-00528-5.
Wolfartsberger, J. (2019). Analyzing the potential of Virtual Reality for engineering design review. Autom. Constr., 104, 27–37, doi:10.1016/j.autcon.2019.03.018.
Wolfartsberger, J.; Zenisek, J.; Sievi, C.; Silmbroth, M. A virtual reality supported 3D environment for engineering design review. In Proceedings of the 2017 23rd International Conference on Virtual System Multimedia (VSMM), Dublin, Ireland, 31 October–2 November 2017; pp. 1–8.
Zhang, Z.; Peng, Q.; Gu, P. Improvement of User Involvement in Product Design. Procedia CIRP 2015, 36, 267–272. doi:10.1016/j.procir.2015.01.019.