VIRTUAL REALITY

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2. ABSTRACT

Virtual reality (VR) is a technology which allows a user to interact with a computer-simulated environment, whether that environment is a simulation of the real world or an imaginary world. It is the key to experiencing, feeling and touching the past, present and the future. It is the medium of creating our own world, our own customized reality. It could range from creating a video game to having a virtual stroll around the universe, from walking through our own dream house to experiencing a walk on an alien planet. With virtual reality, we can experience the most intimidating and grueling situations by playing safe and with a learning perspective.

Very few people, however, really know what VR is, what its basic principles and its open problems are. In this paper a historical overview of virtual reality is presented, basic terminology and classes of VR systems are listed. An insightful study of typical VR systems is done and finds the challenges of Virtual Reality.

3. INTRODUCTION

The definition of virtual reality comes naturally from the definition for both 'virtual' and 'reality'. The definition of 'virtual' is 'near' and reality is what we experience as human beings. So, the term 'virtual reality' means 'near reality'. This could refer to anything but it usually refers to a specific type of reality emulation.

In technical term, Virtual Reality (VR) is a computer-generated environment with scenes and objects that appear to be real, making the user feel they are immersed in their surroundings. We know the world through our senses and perception system. Human have so many senses including sense of balance, sense of movement, the well-known five senses (sight, hearing, smell, taste and touch) and so many other senses. These sensory inputs, plus some special processing of sensory information by our brains ensures that we have rich flow of information from the environment to our minds.

Today’s virtual reality technologies build upon ideas that date back to the 1800s, almost to the very beginning of practical photography. In 1838, the first stereoscope was invented, using twin mirrors to project a single image. That eventually developed into the View-Master, patented in 1939 and still produced today. The use of the term 'virtual reality', however, was first used in the mid-1980s when Jaron Lanier, founder of VPL Research, began to develop the gear, including goggles and gloves, needed to experience what he called 'virtual reality'.

Even before that, however, technologists were developing simulated environments. One milestone was the Sensoria in 1956. Morton Heilig’s background was in the Hollywood motion picture industry. He wanted to see how people could feel like they were 'in' the movie. The Sensoria experience simulated a real city environment, which you 'rode' through on a motorcycle. Multisensory stimulation let you see the road, hear the engine,

feel the vibration, and smell the motor's exhaust in the designed 'world'. Heilig also patented a head-mounted display device, called the Telesphere Mask, in 1960. Many inventors would build upon his foundational work.

By 1965, another inventor, Ivan Sutherland, offered 'the Ultimate Display', a head-mounted device that he suggested would serve as a 'window into a virtual world'. The 1970s and 1980s were a heady time in the field. Optical advances ran parallel to projects that worked on haptic devices and other instruments that would allow you to move around in the virtual space. At NASA Ames Research Center in the mid-1980s, for example, the Virtual Interface Environment Workstation (VIEW) system combined a head-mounted device with gloves to enable the haptic interaction.

Today, virtual reality is current and very newsworthy subject in the world. There are 3 primary categories of virtual reality simulations used today:

1- Non-immersive virtual reality: this technology provides a computer-generated environment, but allows the user to stay aware of and keep control of their physical environment.
2- Semi-immersive virtual reality: technology provides realism through 3D graphics, a term known as vertical reality depth. This one is used in education and training.
3- Fully-immersive simulation: this technology allows the user to experience and interact with fully-immersive virtual reality, the user needs the proper VR glasses or a head mount display (HMD).

4. VIRTUAL REALITY COMPONENTS

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.

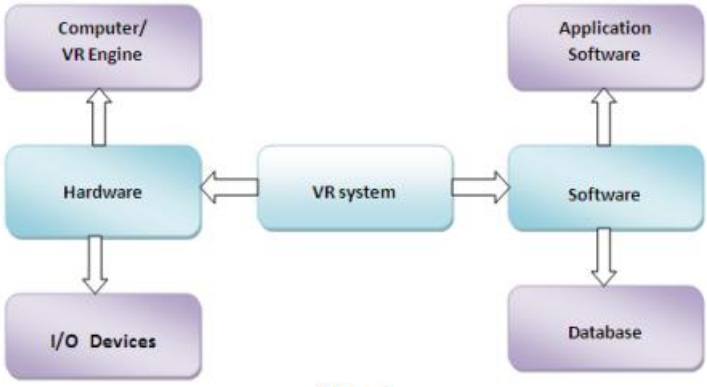

Fig. 1

4.1 Virtual Reality System Hardware

The major components of the hardware are the VR engine or computer system, input devices and output devices shown in fig. 2 below.

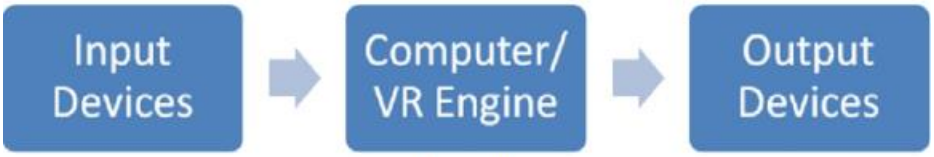

Fig. 2

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.

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 has to 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. The computer also handles the interaction with users and serves as an interface with the I/O devices.

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.

4.2 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. 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

Below are some of the key elements in Virtual Reality technology:

- A virtual world
- Immersion
- Sensory feedback
- Interactivity

4.3 Virtual world in Virtual Reality

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.

4.4 Immersion in Virtual Reality

Immersion in a virtual environment means the perception of presence in a non-physical or virtual world. A state of complete immersion is said to be present when enough human senses are stimulated to create a sensation of existing in the virtual world.

Types of Immersion in Virtual Reality:

There are two types of immersion in VR:

- Mental Immersion
- Physical Immersion

Mental Immersion

A deep engagement state where our mind suspends the disbelief that we are in virtual environment.

Physical Immersion

Physical engagement demonstrated in the virtual world that makes our mind to suspend the disbelief that we are in a virtual environment.

4.5 Sensory Feedback in Virtual Reality

Virtual-Reality puts many of our senses to play. These include visual, touch, aural and more. Sensory feedback is required for properly stimulating these senses. This is achieved through the integration of proper software and hardware components.

Head mounted displays (HMD), hand accessories, hand controls and special gloves are few examples of inputs and hardware devices.

4.6 Interactivity in Virtual Reality

Interaction is a very important factor for VR technology to function. It provides users with comfortable, natural experience in engaging with the virtual world. The virtual environment must be quick enough to respond to the user's action.

This is required to maintain excitement and a mood of immersion. If the interaction is slow, then there will be no immersion and the virtual experience will fail to excite the user.

5. VIRTUAL REALITY DEVICES

5.1 Virtual Reality Headset (HMD Headset)

5.1.1 Tethered VR Headset (High-end VR Headsets, PC VR, Desktop VR)

Tethered VR means that the headset is physically connected to a computer by cables, such as HDMI and/or USB. Tethered virtual reality headsets are currently much more immersive than other types of VR due to the high-quality experience they can deliver. These premium VR headsets require a certain amount of setup space as well as a constant cable connection to a powerful gaming PC (generally a very expensive acquisition).

A few manufacturers are starting to create PC VR headsets that require less computing power. However, this typically means sacrificing tracking accuracy and graphics quality. Thanks to Intel's WiGig (Wireless Gigabit) technology, wireless adapters exist to combine the best of both worlds: freedom of motion in combination with high-quality VR experiences powered by a high-performance computer.

Pros of desktop VR:

- High-end virtual experiences
- Access to quality virtual reality content

Cons of desktop VR:

- Limited freedom to move
- Requires room space and an advanced cable management system
- Hidden costs (PC, controllers, sensors, and cameras)

5.1.2 Standalone VR Headsets (all-in-one HMDs)

This category of headsets requires the least external interaction; standalone headsets are plug-and-play, minus the plug. Apart from charging the battery and perhaps creating an account to access certain VR platforms, standalone VR headsets don't need anything else from the user.

Indeed, standalone VR headsets have built-in processors, sensors, batteries, storage memory, and displays, so they don't require a connection to a PC or a smartphone. That is why users also refer to them as all-in-one VR headsets. Since they are wireless, users don't have to limit themselves to their living rooms.

Generally speaking, all-in-one virtual reality headsets are much less powerful than PC headsets. They offer lower-quality graphics and lower refresh rates. However, various important tech companies such as Google, Facebook, and HTC seem to be focusing more and more efforts on this VR category. Indeed, the future lies in wireless yet powerful virtual reality, rather than in tethered VR headsets. At some point, these categories will be more dominant in VR as they are more affordable and dynamic.

Pros of standalone VR:

- Wireless
- No hidden costs

Cons of standalone VR:

- Less powerful than tethered headsets
- Battery life

5.1.3 Smartphone VR Headsets and Handheld VR Viewer

Smartphone VR headsets, as their name indicates, make use of smartphones to provide a virtual reality experience. Users must simply slide their smartphones into the headset; the screen will be right in front of the user's eyes, with a set of lenses that create a sense of depth (like other types of headsets).

It is better to use recently released smartphones, which tend to be the most powerful. The quality of the VR experience indeed depends on the smartphone being used. Varying factors include the type of screen and its resolution. Also, VR apps use the smartphone's camera and built-in accelerometers. Good-quality mobile VR headsets can cost over a hundred US dollars, but there are cheaper solutions, like handheld VR viewers.

Handheld VR headsets– such as the original Google Cardboard– also require a smartphone, but are often made of low-cost materials. Users must hold these VR headsets up to their face to experience VR as there is generally no strapping provided. These are good for limited VR experiences via a smartphone.

Pros of mobile VR:

- Easy to use and many people already own a smartphone
- An affordable introduction to VR

Cons of mobile VR:

- May quickly empty the smartphone's battery
- Limited immersion compared to PC and standalone VR

5.2 Virtual Reality Gloves (Haptic Gloves)

Haptic gloves are part of the equipment that is being used in the development of a wide range of virtual reality devices. Essentially, the haptic glove is a mechanism that is shaped like the human hand. As with any glove, haptic gloves allow for the insertion of the human hand and the easy movement of the fingers. However, haptic gloves also contain electronic wiring and devices that help to stimulate sensation and allow for an interface with electronic images.

The function of haptic gloves is usually built around two main applications. In one type of interactive activity, the gloves allow the wearer to receive stimulation along the fingertips that mimics actual physical contact with an object or another person. The sensations are connected to an electronic simulation, such as in a video game. Haptic technology allows the individual wearing the gloves to not only view the virtual simulation, but also to physically interact with it.

Along with allowing for the creation of an artificial sense of touch, haptic gloves also allow the wearer to move the fingers and impact the movement within the virtual simulation. Thus, the wearer is able to use the gloves to help the virtual self-move around in the virtual

reality and interact with the other elements of the reality. The sense of movement and touch will seem perfectly natural to the person wearing the gloves, and can be very entertaining.

Disadvantages of VR gloves:

- May be tethered.
- May be heavy and awkward to use
- Come at an additional cost

5.3 Virtual Reality Handheld Controllers

With a VR headset, learners see their virtual world. With VR controllers, learners interact with it. VR controllers come in many shapes and sizes depending on their manufacturer, including Oculus, VIVE, Pico, and more.

The quality of VR controllers can vary depending on the manufacturer and generally come with the following capabilities:

- Wireless tracking of hand movements
- Thumbsticks, buttons, and touchpads that allow for interactions with objects and people within the VR environment
- Typically come at no additional cost with the headset

Disadvantages of handheld controllers:

- Limited interactions with virtual objects and people
- Controls aren't always intuitive

6. APPLICATIONS

6.1 Virtual Reality in Military

The military in the UK and the US have both adopted the use of virtual reality in their training as it allows them to undertake a huge range of simulations. VR is used in all branches of service: the army, navy, air force, marines and coast guard. In a world where technology is adopted from an early age and children are accustomed to video games and computers, VR proves an effect method of training. VR can transport a trainee into a number of different situations, places and environments for a range of training purposes. The military uses it for flight simulations, battlefield simulations, medic training, vehicle simulation and virtual boot camp, among other things. VR is a completely immersive, visual and sound-based experience, which can safely replicate dangerous training situations to prepare and train soldiers, without putting them at risk until they are ready for combat. Likewise, it can also be used to teach soldiers some softer skills, including communication with local civilians or international counterparts when out in the field. Another of its uses includes treating Post-Traumatic Stress Disorder (PTSD) for soldiers who have returned from combat and need help adjusting to normal life situations; this is

known as Virtual Reality Exposure Therapy (VRET). A key benefit for using virtual reality technology in the military is the reduction in costs for training.

6.2 Virtual Reality in Sport

VR is revolutionizing the sports industry for players, coaches and viewers. Virtual reality can be used by coaches and players to train more efficiently across a range of sports, as they are able to watch and experience certain situations repeatedly and can improve each time. Essentially, it's used as a training aid to help measure athletic performance and analyze technique. Some say it can also be used to improve athletes' cognitive abilities when injured, as it allows them to experience gameplay scenarios virtually. Similarly, VR has also been used to enhance the viewer's experience of a sporting event. Broadcasters are now streaming live games in virtual reality and preparing to one day sell virtual tickets to live games so that anyone from anywhere in the world can 'attend' any sports event. Potentially, this could also allow for those who cannot afford to spend money on attending live sports events to feel included as they can enjoy the same experience remotely, either for free or at a lesser cost.

6.3 Virtual Reality in Mental Health

As mentioned briefly before, VR technology has become a primary method for treating post-traumatic stress. Using VR exposure therapy, a person enters a re-enactment of a traumatic event in an attempt to come to terms with the event and heal. Likewise, it has also been used to treat anxiety, phobias and depression. For example, some patients with anxiety find meditating using VR to be an effective method to manage stress reactivity and boost coping mechanisms. Virtual reality technology can provide a safe environment for patients to come into contact with things they fear, whilst remaining in a controlled and safe environment. This is just one of the ways virtual reality can have a real positive impact on society.

6.4 Virtual Reality in Medical Training

Due to its interactive nature, medical and dental students have begun using VR to practice surgeries and procedures, allowing for a consequence free learning environment; the risk of inflicting harm or making a mistake while practicing on real patients is eliminated. Virtual patients are used to allow students to develop skills which can later be applied in the real world. Using VR technology in the medical industry is an effective way to not only improve the quality of students in training but it also presents a great opportunity to optimize costs, especially since health services are continuously under pressure with tight budgets.

6.5 Virtual Reality in Education

VR uses for education don't stop at the military or medical field, but extend to schools with virtual reality also adopted in education for teaching and learning situations. Students are able to interact with each other and within a three-dimensional environment. They can also be taken on virtual field trips, for example, to museums, taking tours of the solar system

and going back in time to different eras. Virtual reality can be particularly beneficial for students with special needs, such as autism. Research has found that VR can be a motivating platform to safely practice social skills for children, including those with Autism Spectrum Disorders (ASD). Technology company, Floreo, has developed virtual reality scenarios that allow children to learn and practice skills such as pointing, making eye contact and building social connections. Parents can also follow along and interact by using a linked tablet.

6.6 Virtual Reality in Fashion

A lesser known use of VR is in fashion where it has actually been having quite a profound impact. For example, virtual simulations of store environments can be extremely useful for retailers to design their signage and product displays without fully committing to the build like you would in the real world. In the same way, appropriate time and resources can be allocated for the build of the store layout. Some popular brands that have already begun implementing VR in their business include: Tommy Hilfiger, Coach and Gap. VR uses for these big names encompass offering a 360-degree experience of fashion shows and allowing customers to try on clothes virtually.

7. ISSUES

7.1 Health-Related Risks When Wearing A Virtual Reality Headset

There are several side effects associated with its use. These risks include:

- Headaches
- Nausea
- Eyestrain
- Running into other objects or people

When learners put on a VR headset, they block out their view of the real world and are placed in a simulated environment. This may trigger side effects in the learner's brain if they become disoriented throughout their VR activity. In addition to psychological side effects, learners risk running into other objects or people because their view of the real world is blocked by their headset.

7.2 The High Price Tag

Two components make up the high cost of virtual reality products: the hardware and software. This includes things like VR glasses and a computer that has enough processing power to stream VR content in terms of the hardware. The software aspect is also expensive because companies have to hire developers with specialized knowledge and expertise to create VR products. The high cost of headsets and computers will most likely be resolved as time goes on since VR is a relatively new phenomenon and new products tend to be expensive.

This brings us to the high cost of virtual reality development. While the price tag is high, a lot of companies have been able to achieve various business objectives, thus justifying the costs. Therefore, it's all about having the right business processes and goals in place and then using virtual reality as a means of reaching them.

7.3 Finding the Right Business Model

This is one of the biggest virtual reality issues facing the industry. This is actually a two-sided problem. On the one hand, we have the problem we mentioned above where businesses are not sure how to use VR while the companies producing VR products don't know how to generate revenue with the VR content they created. Such VR challenges can be solved by finding specific pain points the product can resolve. For example, if businesses are struggling with employee training, there need to be specific VR solutions to resolve this pain point. Therefore, VR products need to be more targeted and addressed to fix a specific business problem or achieve an objective.

7.4 Not Enough Creativity

Even though VR reality can simulate real-world experiences, the users want a lot more than that. For example, even though they can test drive a car in VR, it still needs to add something to the experience to make it worthwhile to the user. This is one of the most interesting challenges of virtual reality since it requires both businesses and their technology partners to get creative. Nobody wants to put on VR glasses and live through their boring real-life experience in a virtual world. The good news is that with the right technology provider, you can create virtually any product that will be customized to your needs and they will be able to bring your imagination to life. Therefore, if you take care of the business aspect, the software can always be developed to fit that vision.

7.5 Virtual Reality Ethical Issues

Ethical issues are some of the most widely discussed issues with virtual reality. One of the biggest such VR problems includes isolation. A user can enjoy the virtual world so much, they forget about the real world. This can also lead to problems with social interaction caused by isolation. This leads to another VR challenge of getting the person readjusted to the real world. They may be desensitized to certain types of violence or interactions, which could damage their social relationships. They may also overestimate their physical abilities, attempting a jump they can't make or trying a skill they've only perfected in a VR environment. These are only some of the VR ethical issues being talked about and will need to be resolved as the technology develops.

7.6 Technical Issues

As with any advanced technology, you can expect to experience technical difficulties. These issues could be any of the following:

Login issues — Users may forget their username and password.

Low bandwidth — Your current broadband connection may be slowed down if too many users are connected at once.

Content glitches — The training content itself may have glitches due to poor content design and programming.

Navigation issues — Learners may have issues navigating their VR training program and not know how to make selections, return to the menu, etc.

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