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Virtual Reality: A Technology of Illusion

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Virtual reality is the newly and very emerging technology that provides a new and powerful techniques to the user for interacting with the computer systems. Virtual reality technology has gone a long way and proved its scope and application in various fields such as medical science, entertainment, research and engineering etc. Institutions from all over the world are now investigating this technology with the view to developing commercially viable products. There are number of ways in which Virtual Reality technology can be implemented and these can be placed broadly into three categories; semi-immersive ,desktop, and fully immersive depending on the sophistication of the technologies being used.

Index Term-- Virtual Reality ,VR, VR System, VDU, HMD Motion Tracking

I. INTRODUCTION

We all remember how we interact with computers. Traditional method of interaction with a computer uses the presence of a mouse, keyboard, or joystick/trackball device to input information and the use of a "visual display unit" (VDU) to receive output from the system. But With the development of Virtual Reality (VR) technology its changing and new interaction methods have been developed that allow the user to "step into" computer generated or virtual, environments (VEs) which is achieved by "immersing" the user in the synthetic environment. This can be achieved by various means including the wearing of enclosed "Head-Mounted Displays" (HMDs) which may provide stereoscopic images of the Virtual environments and by tracking the motion of the hands, head, fingers, and other limbs of the body using optical or magnetic tracking systems. Ideally, it is desirable that tracked movements of the body are updated in real time, but some limitations to the currently available technologies dictate that this is not always the case.

Companies like Sony, HTC Oculus, Samsung and Google have contributed a lot in the development of this technology and made it available for the users, and users usually require three thing these are :- A PC, console or Smartphone to run the app or game, a headset which secures a display in front of your eyes (which could be the phone's display) and some kind of input – controllers, head tracking, hand tracking, voice, on-device buttons or trackpads.

A. History

Although the concept of virtual reality technology may sound new and revolutionary to us, but the idea of inclusion within an artificial environment is not new.

In fact VR is considered as an extension of ideas which have used the similar concept of interaction with computer systems, such as flight simulation, Sensorama (Heilig, 1962) and wide screen cinema (such as Cinerama and IMAX). Using such systems, the viewer is presented with a screen which takes up a large portion of the visual field giving a powerful sense of presence or 'being there'.

Two major breakthroughs occurred in the 1960's with the arrival of the minicomputer and the work of Ivan Sutherland in 1965 entitled "The Ultimate Display ". In this paper Sutherland prophesied the development of the first HMD, which he was later to achieve with an HMD called "The Sword of Damocles". Sutherland also realized the potential of computers to generate images for flight simulation, where, previously images were generated using video camera.

These ideas were combined by two NASA Ames scientists, Fisher and McGreevy, working on a project called the 'virtual workstation' in 1984. From these ideas NASA Ames developed the first commercially viable HMD, called the visual environment display (VIVED), which was based on a scuba divers face mask with the optical screen displays supplied from two Sony Watchman hand-held televisions. This development was unprecedented, as NASA had an HMD that could be produced at an affordable price and the VR industry was born.

II. VIRTUAL REALITY

Virtual reality (VR) typically refers to computer technologies that use software to generate realistic images, sounds and other sensations that replicate a real environment (or create an imaginary setting), and simulate a user's physical presence in this environment, by enabling the user to interact with this space and any objects depicted therein using specialized display screens or projectors and other devices.

In simple word, “virtual” is defined as – “almost as described” or ”not physically existing as such but made by software to appear to do so”. And “reality” is – of course the state of things as they actually exist.

So, putting them together gives us a term that means experiencing something that is close to reality: an environment that is created by computer software to appear realistic.

Look around and you understand the world through your senses, of which the main ones are sound, smell, sight, touch, and taste. You experience these feelings and sensations via your main sensory organs: your ears, eyes, mouth and nose, hands (skin).

But you have many more senses than just the five we have rhymed off above. In fact, many neurologists would argue that we have up to 9 senses, while others believe we have over 20. We are not here to debate the accuracy of this, but there are obvious senses beyond the big five, such as proprioception (the brain's knowledge of the relative positions of parts of your body) and balance.

All of these inputs combine to provide you with a rich understanding of the environment around you. And if you were able to fool your senses into believing that the world around you was real by pulling on a VR headset, then your perception of reality would alter.

The signals being sent back to your brain via your sensory organs would in essence inform your brain that the computer-generated virtual world should be perceived as reality, allowing you to immerse yourself in another world, without leaving the comfort of your own home.

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III. TYPES OF VR SYSTEMS

A. *Non-Immersive (Desktop) Systems*

Non-immersive systems, as the name suggests, are the least immersive implementation of VR techniques. Using the desktop system, the virtual environment is viewed through a window or portal by utilizing a standard high resolution monitor. Interaction with the virtual environment can occur by conventional means such as mouse, keyboards and trackballs or may be enhanced by using 3D interaction devices such as a Data Glove or Space Ball .

The non-immersive system has main advantages in that they don’t require any special hardware and the highest level of graphics performance, and can be implemented easily on high specification PC clones. This means that these non-immersive systems can be regarded as the lowest cost VR solution which can be used for several many applications. However, this low cost means that these systems will always be beyond performed by more sophisticated implementations, provide almost no any sense of immersion and are limited to a certain extent by current 2D interaction devices. Additionally, these systems are of little use where the perception of scale is an important factor. However, user would expect to see an increase in the popularity of such non-immersive systems for VR use in the near future. This is due to the fact that “Virtual Reality Modeling Reality Language” (VRML) is expected to be adopted as a de-facto standard for the transfer of 3D model data and virtual worlds via the internet. The advantage of VRML for the PC desktop user is that this software runs relatively well on a PC, which is not always the case for many proprietary VR authoring tools. Furthermore, many commercial VR software suppliers are now incorporating VRML capability into their software and exploring the commercial possibilities of desktop VR in general.

B. *Semi-Immersive Projection Systems*

Semi-immersive systems are a relatively new implementation of VR technology and borrow considerably from technologies developed in the flight simulation field.

A semi-immersive system will comprise of a relatively high performance graphics computing system which can be coupled with either:

- A large screen projector system
- Multiple television projection systems
- A large screen monitor

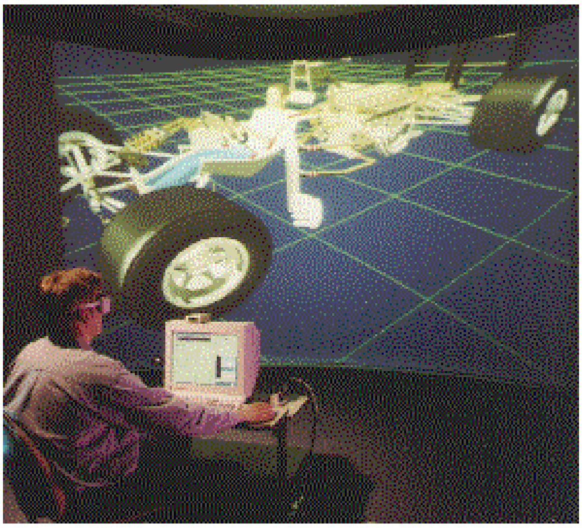
In many ways, semi-immersive projection systems are similar to the IMAX theatres discussed in section 1.1. Using a wide field of view, these systems increase the feeling of immersion or presence experienced by the user. However, the quality of the projected image is an important consideration. It is important to calibrate the geometry of the projected image to the shape of the screen to prevent distortions and the resolution will determine the quality of textures, colors, the ability of define shapes and the ability of the user to read text on-screen. The resolutions of projection systems range from 1000 - 3000 lines but to achieve the highest levels it may be necessary to use multiple projection systems which are more expensive.

Semi-immersive systems therefore provide a greater sense of presence than non-immersive systems and also a greater appreciation of scale. In addition, images can be provided that are of a far greater resolution than HMDs and this implementation provides the ability to share the virtual experience. This may have a considerable benefit in educational applications as it allows simultaneous experience of the VE which is not available with head-mounted immersive systems. Additionally, stereographic imaging can be achieved, using some type of shuttered glasses in synchronization with the graphics system.

Shutter Glasses

"Liquid Crystal Shutter" (LCS) glasses are an important technology when considering semi-immersive systems and consist of a lighter headset with a liquid crystal lens (LCL) placed over both eye. Stereopsis works on the principle that in order to perceive depth in a scene, the observer must see slightly different images of the scene under regard in each eye. In reality this occurs because the eyes are placed slightly apart in the head, and so both eye views the scene from a slightly different position.

The graphics computer used displays slightly different left and right views (known as a stereo pair) of the virtual environment sequentially on the display system. To achieve the stereoscopic effect, the glasses either pass or block an image that is produced on the VDU or projected display. When the left image is displayed, the left eye lens is switched on, allowing the viewer's left eye to see the screen. The right eye lens, however, remains off, thus blocking the right eyes view. When the right image is displayed, the opposite occurs. This switching between images occurs so rapidly that it is undetectable by the user, who fuses the two images in the brain to see one constant 3D image.



A semi-immersive wide-screen projection system in use with shutter glasses.

Examples of this product commercially available include "Crystal Eyes Shutter Glasses" and the "3 Dimension Max Shutter Glasses System".

Again however, the increased performance of this Virtual Reality implementation comes at a cost. Setting up a projection screen system is far more difficult than a desktop system and is considerably more expensive. Additionally, there are problems with current interaction devices for these systems. Firstly, one must consider carefully the applications that such a system may be used for. For a flight simulation system it is possible to simply used an inceptor (joystick) which can be interpreted by the aircraft model as the flight control input. This is acceptable as the simulator is not used for any other applications but becomes problematical when one considers that a semi-immersive installation may have multifarious uses that may require different interaction strategies. Secondly, one must consider multi-user issues, as this is one of the main advantages of these systems. The handover of control between users is one of the issues that must be considered as this technology develops.

C. Fully Immersive Head-Mounted Display Systems

The most direct experience of virtual environments is provided by fully immersive VR systems. These VR systems are probably the most widely known "VR implementation" where the user either wears an HMD or uses some form of head-coupled display such as a "Binocular Omni-Orientation Monitor" or BOOM (Bolas, 1994).

HEAD MOUNTED DISPLAYS (HMDS)

An HMD uses small monitors placed in front of each eye which can provide stereo, bi-ocular or monocular images. Stereo images are provided in a similar way to shutter glasses, in that a slightly different image is presented to each eye. The major difference is that the two screens are placed very close (50-70mm) to the eye, although the image, which the wearer focuses on, will be much further away because of the HMD optical system. Bi-ocular images can be provided by displaying identical images on each screen and monocular images by using only one display screen.

The most commonly used displays are small Liquid Crystal Display (LCD) panels but more expensive HMDs use Cathode Ray Tubes (CRT) which increase the resolution of the image. The HMD design may partially or fully exclude the users view of the real world and enhances the field of view of the computer generated world. The advantage of this method is that the user is provided with a 360□; field of regard meaning that the user will receive a visual image if they turn their head to look in any direction.

All fully immersive systems will give a sense of presence that cannot be equaled by the other approaches discussed earlier, but the sense of immersion depends of several parameters including the field of view of the HMD, the resolution, the update rate, and contrast and illumination of the display.

Fully immersive Virtual Reality systems tend to be the most demanding in terms of the computing power and level of technology (and consequently cost!) required to achieve a satisfactory level of realism and development is constantly underway to improve the technologies. Major areas of research and development include field of view vs resolution trade-offs, reducing the size and weight of HMDs and reducing system lag times.

The major components of an HMD. This illustration shows the two screens capable of producing stereo images and speakers located to provide stereo sound.

IV. VR - HMDs [7]

VR headsets like Oculus Rift [2] and PlayStation VR [6] are often referred to as HMDs and all that means is that they are head mounted displays. Even with no audio or hand tracking, holding up Google Cardboard to place your smart phone's display in front of your face can be enough to get you half-immersed in a virtual world.

The goal of the hardware is to create what appears to be a life size, 3 Dimension virtual environment without the boundaries we usually associate with TeleVision or computer screens. So whichever way you look, the screen mounted to your face follows you. This is unlike AR which overlays graphics onto your view of the real world.

Video is sent from the console or computer to the headset via a HDMI cable in the case of headsets such as HTC's Vive [3] and the Rift. For Google's Daydream headset [4] and the Samsung Gear VR [5], it's already on the Smartphone slotted into the headset.

VR headsets use either two feeds sent to one display or two LCD displays, one per eye. There are also lenses which are placed between your eyes and the pixels which is why the devices are often called goggles. In some instances, these can be adjusted to match the distance between your eyes which varies from person to person.

These lenses focus and reshape the picture for each eye and create a stereoscopic 3D image by angling the two 2D images to mimic how each of our two eyes views the world ever-so-slightly differently. Try closing one eye then the other to see individual objects dance about from side to side and you get the idea behind this.

One important way VR headsets can increase immersion is to increase the field of view i.e. how wide the picture is. A 360 degree display would be too expensive and unnecessary. Most high-end headsets make do with 100 or 110 degree field of view which is wide enough to do the trick.

And for the resulting picture to be at all convincing, a minimum frame rate of around 60 frames per second is needed to avoid stuttering or users feeling sick. The current crop of VR headsets go way beyond this - Oculus is capable of 90fps, for instance, Sony's PlayStation VR manages 120fps.

A. Head tracking

Head tracking means that when you wear a VR headset, the picture in front of you shifts as you look up, down and side to side or angle your head. A system called 6DoF (six degrees of freedom) plots your head in terms of your x, y and z axis to measure head movements forward and backwards, side to side and shoulder to shoulder, otherwise known as pitch, yaw and roll.

There's a few different internal components which can be used in a head-tracking system such as a gyroscope, accelerometer and a magnetometer. Sony's PSVR also uses nine LEDs dotted around the headset to provide 360 degree head tracking thanks to an external PS4 camera monitoring these signals, Oculus has 20 lights but they are not as bright.

Head-tracking tech needs low latency to be effective - we're talking 50ms or less or we will detect the lag between when we turn our head and when the VR environment changes. The Oculus Rift has an impressively minimized lag of just 30 milliseconds. Lag can also be a problem for any motion tracking inputs such as PS Move-style controllers that measure our hand and arm movements.

Finally, headphones can be used to increase the sense of immersion. Binaural or 3D audio can be used by app and game developers to tap into VR headsets' head-tracking technology to take advantage of this and give the wearer the sense that sound is coming from behind, to the side of them or in the distance.

B. Motion tracking

Head tracking is one big advantage the premium headsets have over the likes of Cardboard other mobile VR headsets. But the big VR players are still working out motion tracking. When you look down with a VR headset on the first thing you want to do is see your hands in a virtual space. For a while, we've seen the Leap Motion accessory - which uses an infrared sensor to track hand movements - strapped to the front of Oculus dev kits. We've also tried a few experiments with Kinect 2 cameras tracking our flailing bodies. But now we have exciting input options from Oculus, Valve and Sony.

Oculus Touch is a set of wireless controllers, designed to make you feel like you're using your own hands in VR. You grab each controller and use buttons, thumb sticks and triggers during VR games. So for instance, to shoot a gun you squeeze on the hand trigger. There is also a matrix of sensors on each controller to detect gestures such as pointing and waving. Touch is launching soon.

It's a pretty similar set-up to Valve's Lighthouse positional tracking system and HTC's controllers for its Vive headset. It involves two base stations around the room which sweep the area with lasers. These can detect the precise position of your head and both hands based on the timing of when they hit each photocell sensor on both the headset and around each handheld controller. Like Oculus Touch, these also feature physical buttons too and incredibly you can have two Lighthouse systems in the same space to track multiple users.

Other input methods can include anything from hooking an Xbox controller or joystick up to your PC, voice controls, smart gloves and treadmills such as the Virtuix Omni, which allow you to simulate walking around a VR environment with clever in-game redirections.

V. DISADVANTAGES OF VIRTUAL TECHNOLOGY

The exploitation of this technology has not been without its drawbacks so there are some disadvantage present in VR system. A number of recent reports have suggested that the use of VR equipment may have unwanted physical, physiological and psychological side-effects.

The possible side effects that have been suggested to date can be divided into three main areas. Table 3.2 below, outlines these effects.

Physical
□ physical discomfort □ hygiene □ immersion injuries □ equipment fit
□ unnatural postural demands

Physiological
□ visual asthenopic symptoms □ postural instability □ simulator sickness
□ dissociation of accommodation/ convergence □ cardiovascular change
□ gastrointestinal change □ biochemical change

Psychological	
Behavioral	Cognitive
□ stress □ addiction □ isolation □ mood changes	□ perceptual shifts and disorientation □ changes in perceptual judgment
	□ change in psychomotor performance

VI. THE FUTURE OF VR

As Virtual Reality software becomes more powerful and its hardware more sophisticated, not to mention more affordable, there will be a number of challenges that the industry must face head-on.considering the current scenario, it can be said that VR technology will be made more affordable and accessible to the consumers. also a growth has been seen in its applications. this technology has good impact in its application in medical science, automobiles, gaming, simulations etc.

VR has huge scope in future times, more areas will be adopting this technology that will allow the user to interact in an effective way.

According to the recently report of progress done in the field on VR, it can easily predicted that in future , this technology will be used to give training to the doctors, in computer simulators, in automobile designing, in giving the user a more interactive computer gaming experience, etc.

There will be discussions about its impact on the mental and physical well-being of its users, and restrictions placed on how it is used for more nefarious acts.

But the focus should remain on the positive contributions this technology can make to society. From better healthcare training and education, to active rather than sedentary gaming, there are a number of clear benefits to embracing the exciting developments being made in the world of VR.

VII. CONCLUSION

VR has changed the way we used to interact with technology and computers. In old times we have used inputs and output devices to interact the with the technology. Now with Virtual Reality we can be a part of the technology and then interact in more effective and efficient manner. This technology has discovered new horizon in which technology can interacted, implicated and used. But it can also fools our senses into believing what we see, hear, and even touch to be real, it will without doubted change the way in which we interface with digital information.

It is an very emerging technology and growing very speedily and rapidly, and there are more companies coming forward to invest in its development and make it more and more accessible to the consumers. Also new areas are being discovered where this technology can be used. This way of interacting with the technology has proved to be more effective and efficient over the traditional means.

Using cutting edge hardware and software, VR will impact a wide range of industries, most notably the entertainment industry. And it will also fundamentally improve the way many high-risk professionals are trained in the future.

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