International Journal of Trend in Research and Development, Volume 4(3), ISSN: 2394-9333
www.ijtrd.com

A Study of Virtual Reality

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Abstract: Virtual reality (VR) is a powerful and interactive technology that changes our life unlike any other. Virtual reality, which can also be termed as immersive multimedia, is the art of simulating a physical presence for the audience in places both real and imaginary. It usually involves two senses namely sight and sound. The key property that distinguished VR from all previous media types is "presence". Presence is the psychological sense of 'being there', of actually being immersed in and surrounded by in the environment. This discussion is an attempt to give an overview of the current state of environment-related VR, with an emphasis on live VR experiences. The technology, art and business of VR are evolving rapidly. The various fields of VR are discussed to get a better view about it. The next development based on virtual reality is augmented reality.

Keywords: *Multimedia, Sight and Sound, Presence*

I. INTRODUCTION

"VR is a very high end computer interface that evolves real time simulation and interface through numerous sensorial channels. These sensorial modalities are visual, aural, tangible, smell, taste and other senses."[1]The first traces of virtual reality came from theshort story "Pygmalion's Spectacles" in 1935by Stanley G. Weinbaum's is recognized as one of the first works of science fiction that see the sightsof virtual reality. It describes a goggle-based virtual reality system with holographic demo of fictional experiences including aroma and feel. [3]A very important feature of virtual reality is the environment in which it takes place and must be vigilantly engineered to achieve a realistic experience. For example, if even the least of elements in a virtual reality environment is out of place, the entire experience can be smashed. For the it to be believable, it must achieve at least some height of **immersion**.[2]Immersion is one of the main goals of virtual reality and when a virtual environment is created, it should be created with a view in the path of immersion. When immersion happens, the factual world can often be forgotten. [2] Some characteristics of virtual reality are:

- A simulated environment.
- Involves in computer-generated graphics.
- 3-dimensional.
- Very interactive.
- Involves in the use of human senses.
- exists in several different forms. [4]

II. VIRTUAL REALITY

A. Applications and key areas:

Virtual reality applications can be classified as:

1. The simulation of real environments such as the inner of a building or a spacecraft often with the purpose of training or education.
2. The development of afictional environment, typically for a game or educational adventure. [6]

Areas in which Virtual Reality applications are commonly used are:

- Design Evaluation (Virtual Prototyping)
- Architectural Walk-through
- Development and Maintenance
- Data Visualisation and Concept Visualisation
- Operations in dangerous or remote environments
- Training and simulation
- Sales and Marketing
- Entertainment and Leisure
- Enhanced Realities[vi]
- human factors and ergonomic studies
- simulation of assembly sequences and maintenance tasks
- aid for the handicapped
- study and treatment of phobias (e.g., fear of height) [5]

B. Types of Virtual Reality Environments:

There are numerous types of virtual reality environments, each with their own level of immersion and features. Some of them are below:

- Semi-Immersive Virtual Reality
- CAVE Fully Immersive Virtual Reality
- Collaborative Virtual Environments

Depending on the kind of environment, the level of immersion will differ. For instance, a semi-immersive environment does not aim for complete immersion, which allows it to operate at costs much less than the CAVE. On the other hand, total rendezvous is not possible, which the CAVE can easily accomplish. Collaborative environments are a special instance in which they may or may not aim for complete immersion but the main goal is to share a virtual experience with real people. The type of virtual reality environment chose when it is totally dependent on budget and the goals of the project. For example, the air force practices a virtual reality flight simulator as a training tool. This is one example of a semi-immersive virtual reality environment. A fully immersive environment would just not be necessary.

A fully immersive environment, on the other hand, would be needed for total rendezvous and are a consistent source for research into various principled issues surrounding virtual reality.[2]

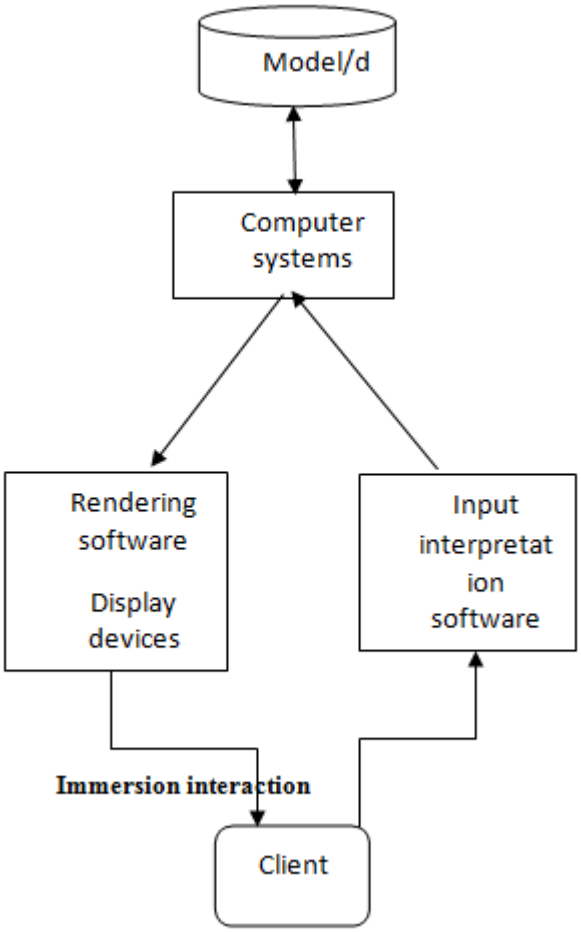
C. Definition of immersion and presences in virtual reality

There are several research papers describe the definition of Immersion and Presences. Most of them mention presence to the subjective sensation of "being there" experienced. So I can conclude that:

- **Immersion** is an account of the ability of computer displays to deliver a virtual environment to users.
- **Presence** is an account of user's particular psychological response to a virtual environment.

The components of immersion are limited to software and hardware of the system. In another hand, different users can experience different levels of presence with the similar virtual reality system depending on life experience: memory, ability, past experience, emotional stare, and another factor. [1]

Interacting with a virtual environment is another key factor of a VR experience. Virtual reality system must able to capture inputs from users for changing the virtual environment endlessly such as the visual display of a virtual reality system reply to a user's physical movement and simulate force back to the haptic device when user move the tool to smash something in virtual environment. [1]



III. FORMS OF VIRTUAL REALITY

A. Immersive first person:

Immersive systems linking computer interface devices such as a head-mounted display (HMD), position tracking devices, fibre-optic wired gloves, and audio systems providing 3-D (binaural) sound. Immersive virtual reality provides a first-person experience immediately. With some applications, there is a treadmill interface to simulate the experience of walking through virtual space. And in place of the head-mounted display, there can be a BOOM viewer from Fake Space Labs which hangs deferred in front of the viewer's face, not on it, so it is not as heavy and strenuous to wear as the head-mounted display. In immersive VR, the user is placed inside the image; the generated image is assigned properties, which make it look and turn real in terms of visual perception and in some cases aural and tangible.

B. Augmented Reality:

A difference of immersive virtual reality is Augmented Reality where a see-through layer of computer graphics is superimposed over the real world to highlight certain features and enhance understanding. One application of augmented reality is in aeronautics, where certain controls can be highlighted, for example the controls needed to land an airplane. Andnumerous medical applications are under development. Recently, for the first time, a surgeon conducted surgery to remove a brain tumour using an augmented reality system; a video image superimposed with 3-D graphics helped the doctor to see the site of the operation more effectively. [8]

C. Through the window:

The most common type of VR is called through-the -window VR is applied extensively in games and movie theatres. It allows a participant to look into the virtual world from a seat in the real world. The "window" the user looks through may be as small as home computer monitor or as large as a movie screen. Although, movie theatres allow for no true interactivity, computer games allow some interactivity between the user and the virtual scene. The images are always real-world video photographed with a camera. In some cases, the seats move and shake in response to image portrayed, e.g., rollercoasters. Any participantwho looks away from the screen during the VR experience "falls out" of the world and back into the real world. But the sensations of speed and hasty movement while looking at that world can be convincing. [9]

D. Secondperson:

The uses of second person VR are to capture the image of a participant and insert it into the virtual world. Users the watch their own images on a monitor interacting with objects in the virtual world. In most applications of this type, the insertion of the participant's image is done by Chroma-keying. This sometimes creates highlights around the participant or mage-resolution differences between the participant and the background. In addition, it often takes some amount of practice to co-relate one's own body movements with what is happening on the screen. [9]

E. Telepresence:

Telepresence is a difference on visualizing whole computer generated worlds. This technology links remote sensors in the real world with the wits of a human operator. The remote sensors might be located on a robot, or they might be on the ends of WALDO like gears or tools. Fire fighters use remotely functioned vehicles to handle some risky conditions. Surgeons are using very minor instruments on cables to do surgery without cutting a major hole in their patients. The instruments will have a small video camera at the business end. Robots are equipped with telepresence systems have already changed the way deep sea and volcanic exploration is done. NASA plans to use tele robotics for space exploration. [7]Itcan be achieved by building and testing physical architypes. The benefits include reduced costs in both design and manufacturing as physical prototyping and testing is intensely reduced/eliminated and lean but robust manufacturing processes are selected. [10]

F. Mixed Reality

Merging the Telepresence and Virtual Reality systems can give the Mixed Reality or Seamless Simulation systems. Here the computer-generated inputs are fused with telepresence inputs and/or the users view of the real world. A surgeon's view of a brain surgery is covered with images from earlier CAT scans and real-time ultrasound. A combatant pilot sees computer generated maps, plans and data displays inside his fancy helmet screen or on cockpit displays. [7]

IV. VIRTUAL REALITY DISPLAY

Four main displays in Virtual reality are the big multiplier for immersion they are:

- Visual display
- Audio display

- Haptic display
- Vestibular display

A. Visual display

Users are hard to feels "being there" if they cannot see things by their eyes. So most of virtual reality systems are focus on visual display. Visual immersion has numerous factors including:

- **Field of view (FOV):** the size of the visual field (in degrees of visual angle) that can be viewed instantaneously.
- **Field of regard (FOR):** the total size of the visual field (in degrees of visual angle) surrounding the user.
- **Pixel per inch (PPI):** the measurement of the pixel density (resolution).
- **Stereoscopy:** the display of two slightly offset images to each eye to provide an additional depth cue.
- **Frame rate:** represents how numerous images that rendered by system every second.
- **Refresh rate:** represents how numerous images that reconstructed by visual display in every second.

Example, to display 24 frames per second on a TV with a 120hz refresh rate, each frame is repeated 5 times every 24th of a second.

To render the realistic environment, the virtual reality system much as able to tracking the position and rotation of user's head for rendering images according to user's eye view.

B. Audio Display

Sound is the very simple way to make listeners notice sense of place, something there, something happening or will happen in virtual environment. The high-quality sound can help in creating a fascinating experience, even when the quality of the visual presentation is lacking. 3-D sound has the advantage over vision in that virtual sound sources can be synthesized to occur anywhere in the 360-degree space around a listener. Audio immersion has numerous factors, including:

- **3D localization:** the virtual reality system must able to tracking the position and rotation of the listener; for example, sounds should get louder as the listener moves nearer to the sound sources and sounds should generate from the same place in virtual environment when the listener rotate his/her head.
- **Sound delivery method:** Different audio channel will give a different sense of sound such as 2, 2.1, 5.1 and 7.1 channels, or headphone.
- **Variety:** Loops and repetitions of sound can be detected and perceived as unrealistic. Creating sound that does not repeat at a rate perceived by the listener will improve the immersion of the virtual reality system.

C. Haptic displays

Haptic display is device that stimulates the sense of touch to user. Now a day, we can see a lot of haptic device in gaming industry such as a driving wheel joystick that has force feedback, a vibration gamepad or even vibration mobile phone. There isnumerous information represented by haptic display include surface properties of object in virtual environment including texture, temperature, shape, viscosity, friction, deformation, inertia and weight.Moreover, haptic display allow user to feel the difference between hard and soft tissues which very important in medical surgery applications.

D. Vestibular display:

The vestibular perceptual sense maintains balance. Vestibular display allows humans sense equilibrium, acceleration, and orientation with respect to gravity in virtual environment. There is a strong relationship between the visual and vestibular systems. Inconsistency between vestibular and visual systems can lead to nausea and motion sickness. Vestibular display is common in flight and driving simulation systems. [1]

V. SOME OF THE TECHNOLOGIES THAT ARE DEVELOPED WITH THE HELP OF VIRTUAL REALITY

A. VR headsets

VR headsets aim to increase the immersion of the user, attempting to make the borders between the real and the virtual world very thin. This could be used either in gaming, or in other cases, such as navigating a real space that has been modelled and converted into a 3D application, medical or education applications etc.

B. Google Cardboard

Google Cardboard is a virtual reality (VR) platform developed by Google for use with a foldout cardboard mount for a mobile phone. It's a low cost device, which enables everyone to jump inside the VR world, but there is a problem. Cardboard only offers the user the ability to navigate by head tracking mechanisms and to interact with only one magnet trigger, removing the feel of emerging inside the VR world.

Therefore, they implemented a way to add more functionality to the Google Cardboard by using a secondary device to navigate and interact inside a scene. The secondary device can be used as a controller to point inside the scenery and also as a way to move. In order to achieve that immersion, at least three things are required:

C. Head tracking

Head tracking is essential for VR applications. Initially, we started with 3 degrees of freedom (3DOF), allowing to map real-world head rotation into virtual-world camera rotation. Oculus then improved on that, using IR LED sensors, thus enabling 6DOF head tracking, which means that also real-world head movements are translated into virtual world camera movement. Low latency is a key requirement, to prevent negative impact on user experience.

D. Stereoscopic 3D rendering:

The screen is split (vertically) in two halves, each one displaying a different frame. In fact, the screen output is the result of two cameras with different position and angles, aiming to emulate the eyes and the human stereoscopic vision. Those two frames are each projected to the appropriate eye using two lenses. The quality of the display, such as the resolution, response time and colour reproduction, all matter to achieve a good result. For example, a low resolution screen reduces the immersion as the user can observe what is called the "screen-door" effect, the distinctive borders of each pixel. Another worse example, is a display with a slow response time or a low motion resolution. This will result in motion blur as the user navigates the virtual space or even a noticeable latency between the user's movements and the movement in the virtual space. This takes away from the experience and at worst, makes the user feel motion sickness.

E. Intuitive, seamless controls

This is another very important feature of VR;this enables residents to control their heating from one single touch screen or tablet device, or remotely via Apps or the internet. (vii)

F. 3D trackers

Various techniques have been developed to monitor the position and orientation of objects in 3D space, but a popular method that has been used in VR systems for a number of years works electromagnetically. Typically, a stationary transmitter radiates electromagnetic signals that are intercepted by a mobile detector attached to the user's head. When the detector receives these signals, they are decoded to reveal the relative position and orientation between the receiver and transmitter. These signals are then passed on to the run-time system for transmission to the 3D graphics environment. The same Principle is used for tracking the 3D mouse, whose signals are used to control an icon in the user's field of view.

G. Gloves

The Data glove developed by VPL can monitor the status of the user's fingers. This is achievedwith thin fibre-optics attached to the back of the glove's fingers. When the user's fingers are flexed, the optical characteristics of the fibre optics alters, which can be measured and scaled into an output signal. As the ability to control finger movements changes from person to person, the glove should be calibrated for an individual to ensure accuracy. A separate tracker is attached to the user's wrist to monitor its position and orientation.

H. 3D mice

A handheld 3D mouse is employed by the user to direct an icon in the user's 3D graphic interface. Its position and orientation are also monitored similar to the method used for the user's head. The mouse also has various buttons whose status are continuously sampled and used to signal to the real-time operating system to move forwards or backwards within the VE. One button is always used to 'pick' a virtual object when it intersects with the3D icon associated with the mouse. In this way the user can identify specific objects and manipulate them within the VE. [11]

I. Virtual reality for learning/training system

Virtual reality system has the potential to make a difference, to guild learners to new knowledge, to motivate and encourage at every level of education. The following reasons to use virtual reality in education are:

- **Providing new forms and methods of visualization:** Virtual reality display allows learners to observe visual objects that may not able to do like in the real world.
- **Motivating students:** Virtual reality system allow learner to interact and work with other learners, which can encourage them to have interests in subject matter.
- **Simulating dangerous, expensive situations:** Virtual reality system allow learners to experience difficult tasks that hard/expensive to do in real world such as electrical teaching experiments.
- **Learning from expert:** Virtual reality system allow expert to share their experience to their students such as share their actions during doing a virtual surgery. [1]

CONCLUSION

Virtual reality system is very useful technology that could improve educational into the next level as we can see from numerous advance virtual reality systems that use for training people such as virtual neurosurgery simulation and virtual dentist simulation. I think in next 2 years from now, Virtual reality will be wildly use in numerous industry: games, movies, educations. We will see people have their own VR system at home or in any smart phone.

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