A Review on Virtual Reality

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Abstract

Virtual Reality is a major asset and aspect of our future. 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 gruelling situations by playing safe and with a learning perspective. In this review paper, we present our survey about virtual reality: the levels of virtual reality, the components used, the factors affecting the virtual environment, its origin, future and the challenges to overcome in order to obtain an impeccable virtual reality experience.

Keywords: Levels of Virtual Reality, Immersive Virtual Reality, Image Resolution, Frame Rate, Latency, HMD, CAVE, Virtusphere.

1. Introduction

Virtual Reality (VR) is a computer-simulated environment. It simulates a person's physical presence in the real and imaginary world. It is a fully-immersive, absorbing, interactive experience of an alternate reality in which the participant feels totally immersed in the environment by means of special human-computer interface equipment. Users can feel and touch simulated objects in that environment, giving the perception that these objects really do exist. They can interact with the virtual environment either through the use of standard input devices such as a keyboard and mouse, or through multimodal devices such as a wired glove, polhemus boom arm, and/or omni-directional treadmill. Thus, users interact with real-time virtual 3D objects in an intuitive & natural way, perceiving them as real and getting to understand, analyze and communicate [1].

2. Levels Of Virtual Reality

There are mainly three levels of Virtual Reality [2]:

2.1 Non-immersive

This level is normally experienced on a desktop computer, where the virtual environment is generated without any specific use of hardware or other processes. It can be used for training purposes. If the equipment is available, almost any scenario can be simulated, which eliminates any imminent dangers. Flight simulators can allow pilots to experience and prepare for situations that cannot be implemented or are hazardous and costly to be implemented in real world training. The illusion of being immersed is generated by responsive computer generated characters and actions that can be taken by the user [2].

2.2 Sensory-immersive (Semi-immersive)

In this method modeling of the real environment plays an important role in various virtual reality applications, such as robot navigation, construction modeling and airplane simulation. The user can navigate a visual representation of him within the virtual environment [2]. A common existing example is the CAVE which is a 10'x10'x9' cube in which the user is surrounded by projected images; this provides the illusion of immersion in the virtual environment [3].

2.3 Neural-direct (Fully Immersive)

Neural-direct is the essential concept and the ultimate goal to achieve for virtual reality. This kind of Virtual Reality represents an immersion into a world where the human brain is directly connected to a database and the viewer's current position and orientation. It neglects the equipment and the physical sense altogether and projects a sensory input directly

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into the brain while continuously projecting the user's conscious directly into the virtual world [2].

3. Virtual Reality System

Virtual reality technology is a man-machine conversation technology that produces living simulating environment and simulates diversified behaviour such as exploration and interaction with the environment.
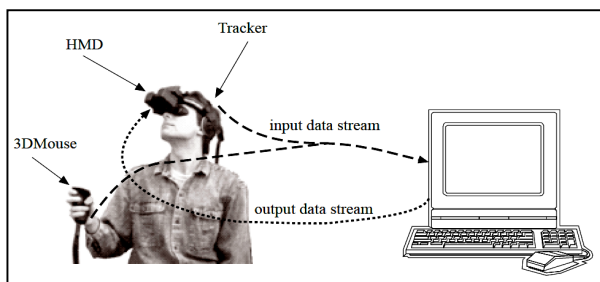
3.1 Components

Fig. 1 Components of Virtual Reality

Figure 1 from [6] depicts the most important parts of the human (to) computer (to) human interaction loop fundamental to every immersive virtual reality system. The user is equipped with a head mounted display, tracker and optionally a manipulation device, for example a wand or a 3D mouse shown in the figure. As the human performs actions like strolling, rotation of head in order to change his viewpoint, description of the data of the user's behaviour is provided to the computer as an input from the input devices. The computer processes information in real-time and renders appropriate result or output that is passed back to the user by means of output displays.

3.2 Design

As figure 2 illustrates, a typical VR system which consists of the following six main components:
1) Virtual World
2) Simulation Engine
3) Graphics Engine
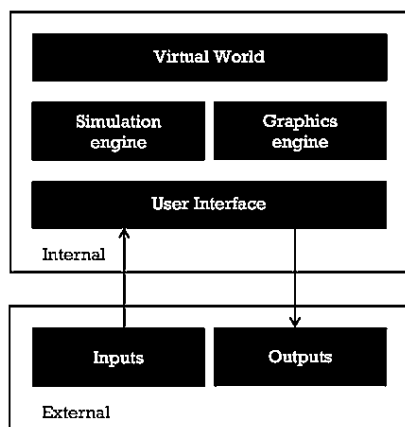4) User Interface
5) User Inputs
6) User outputs

Fig. 2 Internal & External Design of VR

The virtual world, graphics engine, simulation engines and user interface act as the internal components; the user inputs and user outputs act as the external components of the Virtual Reality system. The virtual world consists of a database that is made up of scenes with various geometric representations as well as attributes that the user will see within the environment. The format of these representations depends on graphics and simulations engines used. The graphic engine is responsible for actually generating the image or view of what the participant will actually see in VR world. This is mainly carried out by taking into account the scene database and the user's current position and orientation in the VR world that is according to the head and body movement of the user. The simulation engine's task is to support, keep alive and imitate an artificial (virtual) but real-looking environment. It's responsible to look after the environment's activity – controlling changes with respect to time and reacting to the user's movements and gestures. It also includes handling any interactions or rendering performances of programmed objects and physical simulation. The user interface – a part of the internal components – acts as a middleware connecting the virtual world, simulation engine and graphics engine with the user's input and output devices [5].

3.3 Important Factors

The four important factors of virtual reality are:

3.3.1 Virtual Realism

As the main purpose of the virtual environments is to simulate the real world, we must have knowledge about how to "fool the user's senses". This difficulty is immensely complex: on the one hand we must provide the user with a realistic feeling of being immersed, and on the other hand this solution must be feasible [5].

3.3.2 Image resolution

The images generated by computer are made up of distinct pixels or picture elements. The size and number of these vary according to the display's size and resolution. The pixels cannot be distinctly identified at higher resolutions and hence the screen appears as contiguous to the user. Image resolution mainly consists of the color brightness and shading of what the user sees in the VR environment. There is significant burden on the graphics system since every pixel requires to be illuminated with individual handling of its colour and amount of intensity [5].

3.3.3 Frame Rate

With the goal to achieve a continuous and smooth flowing picture, an older image needs to be replaced by a new one at a very fast rate, i.e., with a high frequency. This system banks on the human phenomenon of persistence of vision. We usually get a contiguous-looking series of images at a rate more than 20Hz – known as the Critical Fusion Frequency (CFF). In order to achieve this rate, the system should replace a new image more than 20 times every second – however, this increases the system's burden [5].

3.3.4 Latency

Latency, also called lag, is an important factor that deals with the degree of realism and tolerability in the virtual setting. It is

the delay induced between the participant's action and associated application response. In the real world, the human senses are accustomed to a certain reaction speed for their actions in various situations. It is necessary to maintain this same speed in the virtual setting, or else the user's senses will become confused as the environment will conflict against the user's used-to-real-world brain. If it takes too long to provide a certain effect to the user in the VR environment the authenticity is lost and the user may be onto a different action in the environment. Hence, the objective of every VR setting is to keep the latency as low as possible for maximum realism [5].

3.4 Navigation and Manipulation in VR System

Manipulation tasks involve selecting and moving objects. Users need to manipulate virtual objects with direct hand manipulation which enables users to relocate or reorient the object. Once the object is selected, the user must be able to move, rotate, scale, change attributes and so on. This is achieved by defining special button presses or hand gestures [12].

Navigation tasks have two main components [12]:

3.4.1 Travel

It involves moving from current location to the desired point.

3.4.2 Way-finding

It refers to finding and setting routes to get a travel goal within the virtual environment.

4. VR Technology In The Making

4.1 The Beginning

The introduction of devices that give virtual experiences set the stage for this technology to make an impact on the way humans could create their own virtual environments

4.1.1 Sensorama

The Sensorama incorporated a well-designed fusion of elements that made the user feel as if he was within the film. Those elements are:
- Projected Film
- Vibration
- Odours
- Audio
- Wind

The Sensorama placed the viewer in a one-person theatre. The viewer's experience encompassed three dimensional coloured films supplemented with perceptions of real motion, natural sound and wind in the face, added with the smells of the virtual environment being seen. The entire experience was pre-recorded, and played back for the user [4].

4.1.2 Head Mount Display (HMD)

Morton Heilig who created the Sensorama in 1956 also invented and patented a device that came to known as the Head-Mounted Display (HMD). A CRT component was attached to the HMD's helmet which was worn by the user. The helmet calculated the head's direction with the help of an installed magnetic tracking system. [4].

4.2 The Present

Virtual reality applications are starting to come into existence with the progress of research in the field and inventions of new technology. VR will give rise to new means of communicating with information and artistic ideas.

4.2.1 CAVE

The cave virtual reality theatre is a projection based system. It consists of a 10 ft^3 cube made up of screens on which the graphics are projected. This setup envelopes the viewers into delusion of being in a real setting. Viewers explore virtual environments by roaming around in the cave's space. Head and hand tracking systems provide the accurate perspective projection from the user's point of view to determine the correct position and orientation of the user. These devices are used for controlling the interaction with the virtual world. Visual effects like video clips sound effects and graphics are also used which provides sound feedback to give more realistic experience in the VR world. The cave has four screens, three surrounding walls and a floor [4].
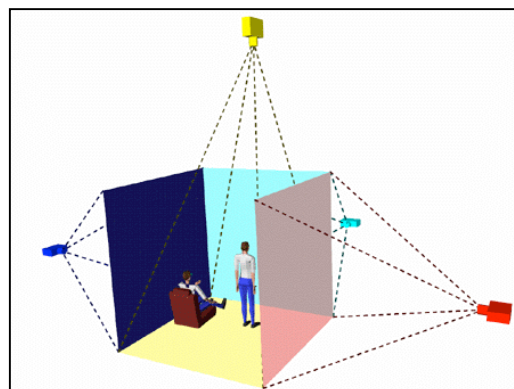

Fig. 3 CAVE (Cave Automatic Virtual Environment)

4.2.2 Architecture

Virtual reality has proven to be promising for taking the engineering level in the architecture and construction industries to a whole new level. Virtual reality gives the freedom to design structural prototypes and explore the surroundings of the architecture; in this way one make modifications to the design before the actual construction begins, thus saving time and huge amounts of costs. In the virtual world, the user can navigate in any direction without any limitations. One can go through the walls or doors without any obstructions [10].

4.2.3 Medical

The VR system significantly reduces complications in surgical operations. The advantage provided by the use of an HMD here is that the patient's body can be manipulated to be translucent or transparent thus exposing the crucial zones in the body clearly. This makes it much easier for the surgeon to operate in the body's correct areas, consequently making the patient's life considerably safer [7]. Virtual reality can be used

in planning radiation treatments for cancer patients. The wonder of VR is that it can even free the disables of their disabilities, allowing them to overcome their physical limitations. Quadriplegics use VR technology to move objects on a computer screen using only their eyes or facial expressions. Biosensors can be useful to control robotic manipulation [5].

4.2.4 Education

Instead of reading about foreign places or watching video–taped program, students can explore new worlds such as foreign countries, ancient times, or the human body. Concept of virtual classroom can be implemented using teleconference. Teleconferencing has allowed for persons at different locations to form a virtual classroom with active classroom discussion [5].

4.2.5 Entertainment

Virtual Reality, as of now, derives its major profit and application in entertainment. The gaming industry surfaces a huge impact on the Virtual Reality field, as the audience for such games is enormous. A user can duck and weave while standing on a sensor pad as in an XBOX and see his movements being reflected in the figure of a boxer fighting a computerized opponent. Similarly, people in so-called cabin rides at some amusement and theme parks confine themselves into chairs that tilt, shake, and jerk as sounds and graphics on a movie-sized screen take them on simulated roller-coaster [8].

4.3 The Future

Virtual Reality will revolutionize the way human's communicate and work. Boosters of virtual reality believe that it will greatly enhance education, science, industry, art, and entertainment, as it has already begun to do. They say it will simplify many tasks and let people express their creativity in new ways [8]. Many people someday will get a glance at the quintessence of VR systems.

4.3.1 Virtusphere

Fig. 4 Virtusphere

Virtusphere is a virtual reality locomotion simulator. It will dramatically change how we play and interact inside virtual environment. This Zorb ball look-alike is mounted on a special stand, which allows free movements and confines the Virtusphere to the place where the stand is. The 10-foot hollow sphere has enough room for one man to step in and any movement made by the user will be aped into the virtual

world [8]. This allows the user to move freely 360 degrees creating the most immersive virtual experience. The user when immersed into the virtual setting is able to navigate (i.e. walk and run) because of the HMD worn. If the user walks in the Zorb, then he walks in the virtual setting; if the user runs in the Zorb, then he runs in the virtual setting too; thus duplicating the user's real-world movements in the virtual setting. Thus, one of the biggest advantages of the Virtusphere is that the hardware set does not require any change at all, since the virtusphere along with the other hardware components provides full freedom of movement. As a result, the virtusphere provides the flexibility to emphasize on the designing of the virtual scenario for different applications [9]. Traditionally PC and console games were played on a static physical position. Virtusphere potentially combines with existing game consoles allow players to be wired into a more actively and or freely and thus creating a fully immersive experience of play.

4.3.2 Engineering

In the times to come, nearly every engineering project will have the flexibility and the freedom to design large-scale virtual-reality blueprints or models – that may be risky to implement without experimenting with small-scale models in the real world – so that actual experience in the real construction can be felt, seen, and modified safely. This will scale engineering to new heights of success and tremendous increase in speed and safety. For instance, in the manufacturing industry, one can simulate how soon a car will experience wear and tear over a period of use, how the repairs will have to be carried out in the most efficient manner – thus saving money and laborious efforts. Given advances in electronic networks, virtual workbenches will be created with engineers in distant locations around the globe working in teams to design products [10].

4.3.3 Medical

In the future, people will approve to mandate the usage of VR in their homes as well as public places. This will empower the people to experiment with the availability and then give assent to the plans. People with physical handicaps will be able to travel new areas virtually, which is a far away from being possible for them in the real world. Disabled people who face the challenges of being restricted in mobility can experience themselves playing various sports like skating and rock climbing in the virtual world [10].

4.3.4 Education

Chemistry students will be able to perform experiments without taking any risks and avoiding any dangerous hazards or accidental explosions in the lab. Astronomy students can travel a range of virtual galaxies without actually sitting in the shuttles to study their properties and explore new worlds of the universe. VR will empower us to re-experience historical events. History students will be able to experience various historical events and perhaps even participate in the movements lead by the historical personalities. English students could earn the experience of on-stage shows of Shakespeare classics – such as Romeo and Juliet at the Global Theatre – in the way they were first performed. Students took dive into fictional books like Harry Potter or Lord of the Rings and interact with their favourite characters and enjoy the fictional world [10].

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4.3.5 Entertainment

Ever wondered an adventure game in which you are immersed in a three-dimensional world, interacting with other users that are connected as participants in a world different from reality. It can become a real, role-playing event. Ever felt about a movie in which you are actually playing a role and interacting with the plot and other characters. In future they will act as a new trend of socializing, which may lead to better and richer relationships in the "real" world [10].

5. Challenges

It is been a tradition that along with technological advancements, the number of complications have simultaneously increased.

5.1 Cost

Designing Virtual Reality systems involves a great deal of investments. Constructing the most ultimate of virtual settings involves complex geometric modeling and incorporating innumerable functionalities for the experience of realism. However, in the present, it costs $250,000 to implement just an elementary virtual environment with limited functionality, freedom and scene databases [11].

5.2 Usability

In the virtual world, a user should be able to perceive information and interact just like in the real world. However, including these features is very intricate, as it demands accounting for various modes of representation of information. Lots of energy is spent in choosing what content structure is apt for the user's activity that needs to be performed in the particular virtual setting [11].

5.3 Modeling Software

In the current commercially available systems, users can participate in virtual worlds only through computer screens. As a result of this, the user does not get the freedom to explore the world with a 360° view. Consequently, the user's involvement in the virtual setting is limited by the size of the screen [11]. To construct a prototype of an airplane or spacecraft and simulating through a particular terrain is one thing, but using VR to model the universe and to make trips to other planets is beyond ones reach at the current point. There are limitations in the form of raw processing power, graphics and even understanding how the brain works [2].

5.4 Dynamic Programming

Constructing the virtual world is not only limited to just the designing and modeling aspect of the surroundings, but it also encompasses the interface with which the user will participate in that environment and the way the feedback is given to the user. For that, we need to acquire the knowledge of the human brain's dynamism – what are the expected reaction times by the brain, how will the eyes perceive the environment, how will the user feel the objects and so on [11].

5.5 Interface Devices

In the real world, our eyes have to continuously change their focus depending on how close or far are the objects to be viewed and how much light is falling on them. However, in commercial VR devices like the HMDs, each picture is focused at infinity for the user. Hence, the eye does not have to adjust its focus. This would lead to the eyes getting stressed because it does not get to exercise and be natural. Thus, in order to provide the experience of realism to the user, the manner in which light illuminates objects, and the way in which these objects are focused by the eye should adhere to the way it works in the real world [11].

6. Conclusion

"The ultimate dream is to merge the real world and the virtual world into a totally seamless experience." – Microsoft PhotoSynth project

Virtual reality has thus finally begun to shift away from the purely theoretical (virtual dream) and towards the practical (a close reality). It is even argued that, if we consider heaven as one giant virtual reality environment, then we can explain resurrection as uploading and reincarnation as the decision to download into another body. With the improvement of the simulation and visual quality of virtual worlds the differences between reality and VR will be constantly disappearing and consequently people may become confused between what is real and what is virtual. This may eventually lead to the lack of responsibility for our actions: one can kill thousands of innocent people not knowing if taking part in virtual simulation or in a real world. Thus VR may become the ultimate drug for the masses. It is our responsibility to choose the right dose.

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