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Survey on Latest Trends, Challenges, & Future Scope in Virtual Reality Applications

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Abstract—*During the last decade a lot of advances in computer hardware, display devices, control devices, software enhancements has tremendously supported Virtual Reality (VR) Technology to grow from leaps to bounds. VR is a systematic scientific technology developed as a part of exploration of nature by humans to deeply understand, simulate and adapt this technology in various engineering applications, entertainment purpose, as a learning aid etc. An in-depth understanding of trends, challenges, future scope for VR systems is discussed. In this survey a conscious effort has been put forward to investigate the state of the art in VR Technologies and its diversified engineering application areas. Various aspects of the design of a VR system are taken into considered like the interface devices for interacting with virtual world, software's, the hardware etc. Also described are a few specific applications that have been developed and possible avenues for future research. Latest trends & evolution of this technology have been touched upon for better understanding. Various applications have been explored and possible approach for enhancing the use of this technology have been discussed. We have discussed some of the limitations in developing such systems. Tools available for development of VR applications that satisfy the current requirements are included. Future directions and suggestions for effectively and efficiently improving the application areas have been focused upon. This paper will provide a better insight for anyone who wishes to do research in the field of VR.*

Keywords*: Virtual Reality (VR), Augmented Reality (AR), Mixed Reality, immersion, display system.*

1. INTRODUCTION

In the year 1965, the founder of Computer Graphics, Sutherland presented the concept of Virtual Reality (VR) system in his paper [1]. This system was named as "The Ultimate Display". It had multisensory display and immersion incorporated into it. This was a pivotal step towards a wider and brighter scope in the field of computer vision and system interaction. The efforts carried out during that stage laid the firm foundation for researchers across to carry out further in-depth analysis and study in this field. This paper is a novel approach in understanding the current state of the art infrastructure and technology available for VR applications, latest trends, challenges and possible future scope. The organization of content in this paper is as mentioned below.

In the next chapter we analyze the basic structure and functions of a virtual reality system and take the three dimensional display as the immersive medium to identify the key issues for construction of virtual environments and to have a better understanding of its technological knowhow. The main emphasis is on the image processing techniques involved in the building of the virtual reality environments and how the process involved can be enhanced with computation speed and graphic quality for better, effective and efficient execution of VR systems. In chapter 3, we discuss some related work prevailing to VR systems, applications, basics and tools and technology are discussed. This will help people to understand the basic requirements for developing VR systems. In chapter 4 we discuss how virtual reality is being classified further with evolvement of technology, various challenges that are to be addressed and possible future scope. In chapter 5 we give a few glimpse of VR applications being developed by us as a part of prototype development phase. Finally we give the concluding remarks in chapter 6 i.e conclusion.

2. BRIEF OUTLINE

The term "virtual reality", was first proposed by Laniner of American VPL Research Inc. In 1989, which described it as a computer simulation technology where using graphics system algorithms virtual objects are developed, using which virtual scenes are created and various simulations based on online programming and offline programming are carried out. Over a period of time with technological advances in display devices, support hardware, software sophistication etc, and VR applications also evolved which was prior to that only in entertainment and simulation training. Nowadays VR applications are in areas of aeronautical research, architecture, scientific visualization in medicine, defense, education, and training etc. From pure entertainment applications there is a huge paradigm shift wherein VR is being incorporated in many intense & critical engineering applications. VR has made huge inroads in medical, telerobotic, training & development type applications.

There are many widely accepted definitions of virtual reality. One definition originates from the human machine interface which is stated [2] as "*virtual reality is a natural interaction technology*". This means that the user can immerse into a computerized environment and make natural interactions with that virtual environment by means of various input devices. The interactions are enabled by specific sensor devices and controlled with dedicated computer graphic and vision programs, scripts, algorithms etc.. The term virtual reality is defined as a means of interaction, by which people can see, operate and interact with extra complex data by the means of computers [3].

Some other definitions are given based on the use of virtual reality devices. One such definition states that virtual reality as being the provision of a three-dimension reality that is realized by a series of sensor devices like head mounted display, data glove, and so on[1]. Here, virtual reality is interpreted as a software and hardware environment wherein co-simulation can be enabled. This environment simulates a real word in which the user can operate and control the virtual environment by special interacting devices such as input systems, sensor bistouries, and video oculars like joysticks, haptic gloves, 3D Space Pilot mouse etc...

In fact, virtual reality technology not only refers to the hardware devices like immersive display, and sensor gloves, but also includes the relating technologies and methods that can generate natural simulation and provide real time experience.

If we go according to the IEEE standard protocol submitted by the "work group of virtual reality term", virtual reality is any computing system which can generate a man-made environment, in which the user can immerse, roam, and operate objects having a look and feel of virtual objects through various sensory devices.

It defines virtual reality as a people-centered closed system that is implemented mainly by computers and uses the corresponding interaction between human and machine with perceptual system [4]. This closed system contains the virtual environment, interface of software and hardware, and the physical environment. With such definition, a virtual reality system has to be supported by necessary devices via which the user can interact with the object of the virtual environment in a natural way and can obtain the real-time experience and feelings of the physical environment by operating the objects in the virtual environment. Importantly, user can overcome the constraints of time and space and control the elements which are intangible in the physical environment.

There are three meanings for being virtual: 1) being in fact, acting as what is described; 2) something assumed and imagined, which does not or is not always in accord with facts; 3) potential, possible[8].

The meaning of reality refers to something which accords with a real object and condition prescribed by some specific rules. The real-time virtual environment dynamically created by computer with dimensional information is the main part of the virtual reality. The environment may conform to a real object or condition and can be operated, or it is only potential or possible [8].

3. RELATED WORK: VIRTUAL REALITY

A brief evolvement of VR technology over the coming years is listed as below [8]:

1929: Edward Link developed a simple mechanical fly simulator in which virtual reality was first applied.

1962: Morton Hailing patented the design called "sensorama" which was an inspiration taken from holographic movies.

1965: the founder of computer graphics, Sutherland [1] inherited and developed the design of Heilig.

1966: funded by the navy scientific research office, American MIT Lincoln Laboratory developed the first head-mounted display (HMD) and applied the feedback devices which simulate the force and tactile in the system later.

1967: inspired by the conception of Sutherland's system, the University of North Carolina launched the GROPE project which researched and developed force feedback devices that made users feel computer simulated force.

1968: organized by Harvard University, Sutherland designed the helmet mounted display and later a virtual system which was considered as the first virtual reality system.

1970: American MIT Lincoln Laboratory developed a full-fledged HMD system.

1973, Krurger presented the term "artificial reality", which was the early term of virtual reality.

1987: Foley published a paper entitled "Interfaces for Advanced Computing" in the journal "Scientific American".

1989: American Jarn Lanier formally presented the term "virtual reality".

1992: Sense8 Company developed the "WTK" package which can provide a higher level application in virtual reality technology.

1994: virtual reality modeling language (VRML) was first formally presented in the first WWW conference in Genovese. After that, many modeling languages of VR have appeared such as X3D, Java3D, and so on.

1994: Burdea and Coiffet[13] published a book about virtual reality in which they summarized the basic characters of VR as 3I (imagination, interaction, and immersion).

2014: Oculus Rift

The list is long and will not be exhaustive. But, one thing is sure with this VR applications will evolve over a period as

technological development happens in various diversified fields.

4. VR CLASSIFICATION

Virtual reality can be classified further.i.e

(a) Immersive virtual reality

(b) Desktop virtual reality (i.e., low cost)

(c) Projection based virtual reality

(d) Simulation based virtual reality

In 1994 Thurman and Mattoon jointly presented a model for differentiating between different types of VR, based on several "dimensions." They identify a "verity dimension" that helped to differentiate between different types of virtual reality, based on how closely the application corresponds to physical reality. They proposed a scale showing the verity dimension of virtual realities (See Fig. 1).

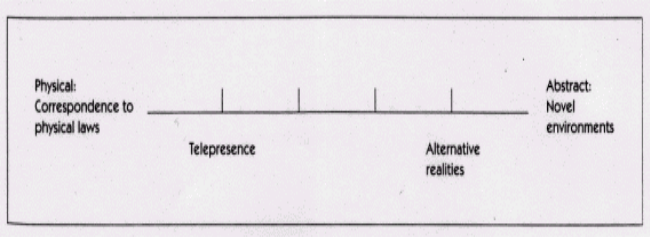

Fig. 1: Scale of VR

As in the figure, the two end points dimension are - physical and abstract ,which describe the degree that a VR and entities within the virtual environment have the characteristics of reality. On the left end of the scale, VR's simulate or mimic real-world counterparts which correspond to natural laws. On the right side of the scale, VRs represent abstract ideas that are completely novel and may not even resemble the real world.

They also identify an "integration dimension" that focused on how humans are able to be integrated into the computer vision system along with VR. This dimension includes a scale featuring three categories: batch processing, shared control, and total immersion. These categories are based on three broad eras of human-computer integration, culminating with VR --- total immersion. A third dimension of this model is interface, on a scale ranging between natural and artificial. These three dimensions are combined to form a three-dimensional classification scheme for virtual realities. This model provides a valuable tool for understanding and comparing different virtual realities.

VR can be assessed on two more distinguishable parameters i.e 2D and 3D (See Fig. 2)

	Less real	More real
1. Dimensionality	2-D	3-D
2. Motion	Static	Dynamic
3. Interaction	Open loop	Closed loop
4. Frame of reference	Outside-in (God's eye)	Inside-out (User's eye)
	World referenced	Ego referenced
5. Multimodal interaction (Enhanced sensory experience)	Limited	Multimodal

Fig. 2: 2D & 3D VR

We can conceptualize the features of VR in terms of two overlapping goals: that of increasing the naturalness of the interface to reduce the cognitive effort required in navigation and interpretation i.e making human interaction with VR system more lively, and that of creating dynamic interaction and novel perspective. It is necessary to maintain the distinctions between these goals clear as we consider the conditions in which VR can operate.

Some challenges that are to be addressed while developing VR systems are:

(a) Developing better tracking systems

(b) Finding more natural ways to allow users to interact within a virtual environment and decreasing the time it takes to build virtual spaces.

(c) There are not many companies that are working on input devices specifically for VR applications. Most VR developers have to rely on and adapt technology originally meant for another discipline, and they have to hope that the company producing the technology stays in business.

(d) For creating virtual worlds, it can take a long time to create a convincing virtual environment - the more realistic the environment, the longer it takes to make it. It could take a team of programmers more than a year to duplicate a real room accurately in virtual space.

(e) Costing of VR Systems

However, with the technological advancement we are able to mitigate the effects of issues involved in VR application development still on display devices side and economical tracking device still remains a challenge. As new researchers are conducting study we can be able to achieve this in coming future, wherein we can expect economical, robust, easy to operate VR application systems in various diversified fields.

5. SOME VR PROTOTYPE APPLICATIONS

As a part of understanding VR applications we had devised some prototype applications for better understanding the use of VR. Various input devices were used for controlling virtual objects.

(a) Virtual Link Arm Control using Mouse

A virtual link arm was controlled using slider mechanism through a mouse.

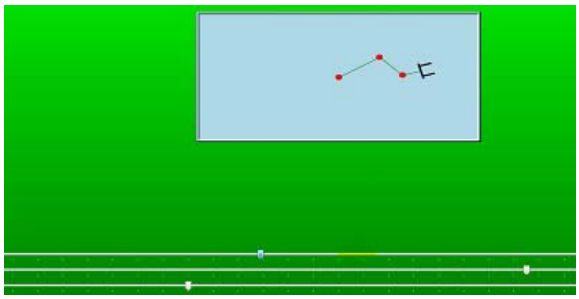

Fig. 3: Virtual Link arm control using mouse

(b) Virtual cube control using Joystick

A virtual cube was translated, rotated and scaled using joystick as an input device for passing various parameters in VR system.

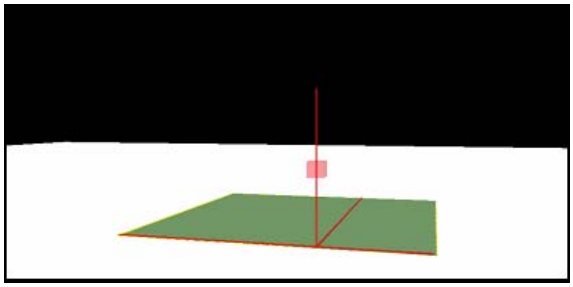

Fig. 4: Virtual Cube control using joystick

(c) Virtual Robot Prototype control using Joystick

A virtual robot prototype was controlled and navigated through in virtual environment using joystick as input device.

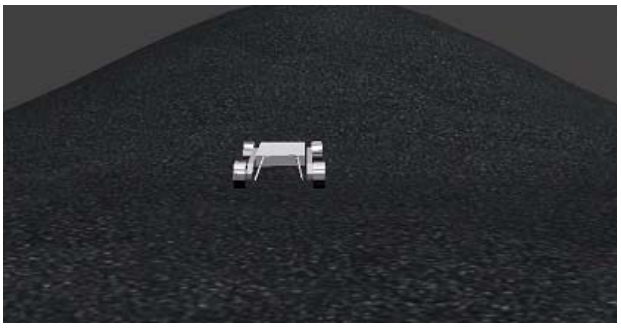

Fig. 5: Virtual Robot Prototype control using joystick

Various tools and libraries are available which work as support system for developing various VR applications.

6. CONCLUSION

With the increase in research outcomes in the field of VR, slowly there is a paradigm shift in VR applications from pure entertainment based VR applications to pure engineering purpose based VR applications like in the field of robotics, medical, civil engineering, mechanical engineering etc. Various tools and integrated libraries have boosted VR application development by resolving some of the traditional issues involved in VR. Development in Augmented Reality has made interaction of human beings with virtual world more immersive, lively and interactive.

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