IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.-7, Issue-4, April 2019 E-ISSN: 2347-2693

Survey on Virtual Reality

[1*]Prabhat K. Pushkar, [2]Vishnu Nair, [3]Himanshu Gupta, [4]Akash Ubbu, [5]Swati Gajbhiye

[1,2,3,4,5]Information Technology, Shah and Anchor Kutchhi Engineering College, Mumbai, India

Corresponding Author: prabhatpushkar07@gmail.com, Contact: +91-9833794263

DOI: https://doi.org/10.26438/ijcse/v7i4.569574 | Available online at: www.ijcseonline.org

Accepted: 10/Apr/2019, Published: 30/Apr/2019

Abstract: Virtual Reality is based on the notion of immersion i.e. a new technological advancement in the field of human machine interaction bringing it closer to real life. It is a technology for simulation of a real or virtual world in which one can immerse, touch, & sense the objects with the virtual presence in that 3-D world. Virtual Reality (VR) is a well-known concept and has been proven to be beneficial in various areas such as entertainment, research, military training, medical training, etc. Also, many applications using VR technology in education have been reported. This paper reviews the ideas & concepts behind the architectural representation, supporting software & hardware implementations, various categorized languages & modelling tools etc. This paper also studies current research objectives, comparison with other virtualized environments, development trends of VR, & modeling methods. Based on the analysis of structure & functioning of virtual reality environment, this paper presents various applications of virtual reality & different categories of issues related to it.

Keywords: *Virtual Reality, Human – Machine Interaction, Modeling and techniques*

I. INTRODUCTION

Virtual Reality aims at addressing as many human senses as possible. The term Virtual Reality (VR) describes a computer – generated scenario of objects (virtual world) the user can interact with. The combination of three-dimensional computer graphics, special display techniques (head-mounted display or stereo glasses) and specific input devices (space ball, data glove, etc.) allows intuitive manipulation of objects in the virtual scenario, thus giving users the impression of being part of the scenario.[7]

Virtual Reality(VR) is a technique for simulation of real or virtual world by applying the theory of immersion into a virtual 3-D space in which stereoscopic vision, sense of hear, sense of touch & sense of smell are very similar to that of real world within a certain area. Virtual Reality is a scientific technology of human-machine interaction for understanding and simulating the real or virtual environment into a 3-D space much like that of real environment & experiencing the nature in a certain range by emerging & showing physical presence into that environment using high performance computers along with sensory equipment. VR also refers to remote communication environments which provide a virtual presence of users with through telepresence and tele-existence or the use of a virtual artifact (VA), either using standard input devices such as a keyboard and mouse, or through multimodal devices such as a wired glove or omnidirectional treadmills. This advancement of technology which is bringing the media closer to the real life has put its footprints in mostly all the real-world applications.

II. HISTORY OF VR

This section contains the literature theory of evolution of VR world showing that it is not a new concept but became popular in this decade. The researches and contributions made by different scientists is described as follows:

Year	Author /Developer	Contribution
1838	Charles Wheatstone	Proposed idea of stereoscope.
1849	David Brewster	Developed lenticular stereoscope that gave birth to sense of depth & immersion.
1929	Edwin A. Link	Created "Link Trainer": a type of commercial flight simulator which is entirely electromechanical.
1950-1960	Morton Heileg	Developed a multi-sensory simulator called Sensorama. It displayed 3-D film in color & with stereo effects.
1961	Comeo & Bryan Philco	Developed the device "Headsight: the first HMD

Year	Corporate Engineers	Contribution
1965	Dr. Ivan Sutherland	Proposed a virtual world creation concept which depicted a vital solution of virtual reality.
1966	Dr. Ivan Sutherland	Constructed a device HMD "Sword of Damocles" with appropriate head tracking which

		later put forward to portray a device which includes graphics, force feedback, sense of touch, taste, sound & smell.
1971	University of North Carolina	Realized the first prototype of force feedback device, GROPE
1973-1975	Myron Krueger	Developed artificial reality "VIDEOPLACE": computer generated environment with no existence"
1982	Thomas Furness	Developed Advanced Flight simulator visually coupled airborne system simulator (VCASS)
1983	US Army & Defense Advanced Research Projects Agency (DARPA)	Implemented a real-time simulation, Simulation NETworking(SIMNET) which results in development of multiuser interactive simulation.
1984	NASA Ames Research Centre	Constructed a visual display named Virtual Visual Environment Display (ViVED) with a stereoscopic monochrome HMD.
1985-1988	Jaron Lanier, the founder of VPL Company	Commercialized the term Virtual Reality with development of popular Data Gloves (1985) and EyePhone HMD (1988)
1989	Fake Space Labs	Developed a VR device BOOM, small box containing two CRT monitors that can be viewed through two eye holes.
1990	NASA Ames Research Centre	Developed Virtual Wind Tunnel (VWT) for analysis of flow fields with the help of BOOM & Data Gloves.
1992	Dr. Carollina Cruz & a team of graduate students at Electronic Visualization Laboratory at University of Illinios, Chicago	Developed 3D projector named Cave Automatic Virtual Environment (CAVE)
1993	Heim	Depicted 7 pillars of VR: Immersion, Simulation, Artificial Reality Interaction, Telepresence, General Immersion, Network communication.
1994	WWW Conference held in Geneva	Concept of VRML was introduced for the first time.

Current Advancements:

In this century, A rapid advancement in the field of VR has been grown with the development of various powerful computer devices & smartphones with high density displays & 3D graphics capabilities. Also, development of various HMDs such as Google Cardboard, Samsung galaxy Gear, Oculus Rift, HTC vive has drove a generation of VR with a fast pace. One, called focus tun-able displays, entails projecting virtual content in multiple focal planes, improving the user experience by tackling issues of visual discomfort. Light field cameras will be crucial to this process. This type of technology—which is currently being made by companies like Lytro— can re-focus pictures even after they have been taken, by harnessing a micro-lens array and special light field sensor to analyse which direction rays of light are entering the camera. Game Industry is growing more rapidly is growing more rapidly.[3] Second life & Active world development has provided simulation of VR on the cloud in different application areas.

III. VR MODELING METHODS

VR modeling refers to modeling of 3D objects, their interaction with virtual & real world, the effect of the interaction on the objects etc. in order to simulate them. This section describes various VR modeling methods & development trends.

A. SCENE APPEARANCE MODELING METHOD

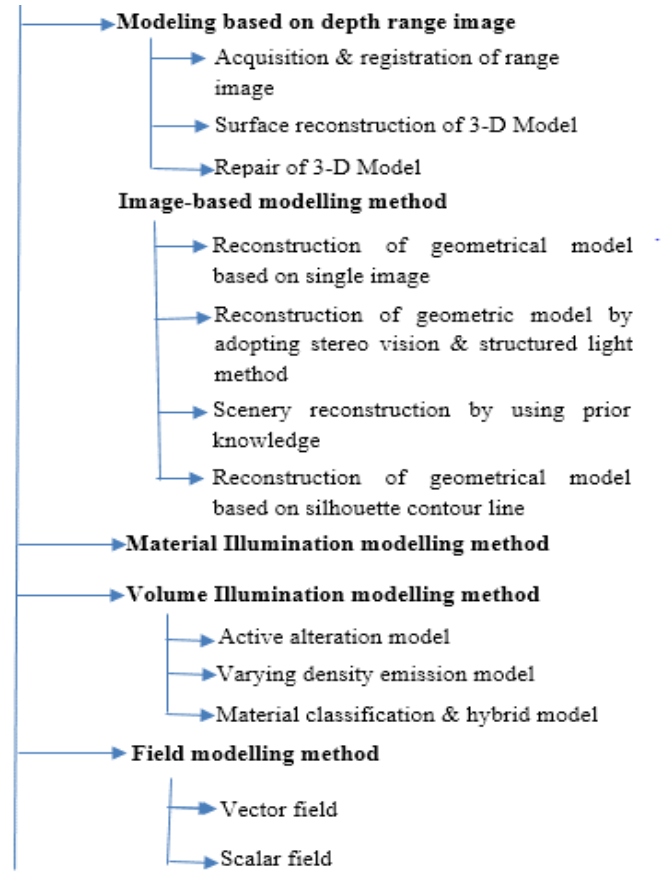

Fig. 1

B. BEHAVIOUR MODELING METHOD

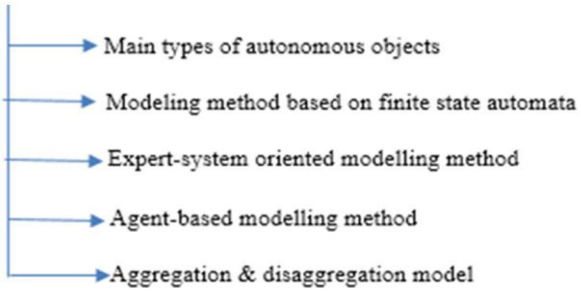

Fig. 2

C. MODELING OF VIRTUAL-REAL COMBINATION

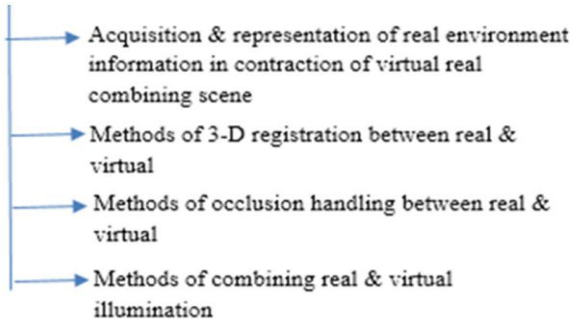

Fig. 3

D. PHYSICAL BASED MODELING METHOD

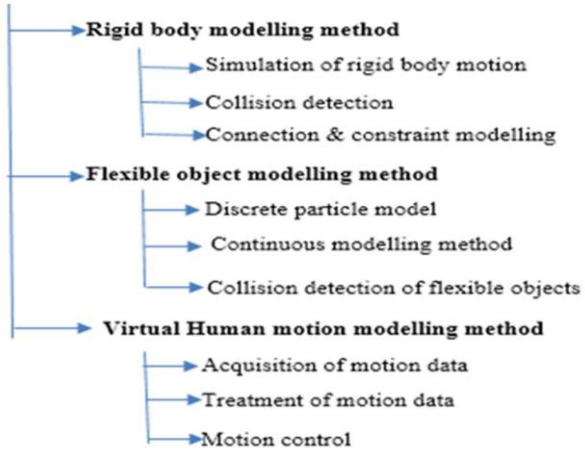

Fig. 4

IV. PRESENTATION TECHNOLOGIES OF VIRTUAL REALITY

VR presentation technology is required to provide user a realistic visual insight, sense of hearing, feeling etc. Various kinds of virtual scenery models in a digital space are rendered on presentation tools by presentation technology using different VR presentation methods & algorithms. This rendering of scenery models is presented to user in way of immersion. The various presentation technologies of VR are as follows**:**

A. AUDITORY PRESENTATION

This presentation technology renders the perception of sense of hearing. A big term for VR audio is spatialization i.e. ability to play a sound positioned at a point in 3D space. It is achieved with the help of Head Related Transfer Function (HRTF). The followings are the techniques of Auditory presentation technology:

- Virtual auditory virtualization
- Acquirement & individualization of HRTF

B. TACTILITY PRESENTATION TECHNOLOGY

This presentation technology is applied to investigate 3D perception of force/ tactility i.e. sense of feeling (touch, smell, emotion etc.). The Tactility

- Collision Detection
- Texture mapping of tactility
- Six degrees of freedom

C. VISUAL PRESENTATION TECHNOLOGY

This presentation technology renders the visual insight in a 3D virtual world. There are following technologies for rendering visual perception. Various visual presentation technologies are as follows:

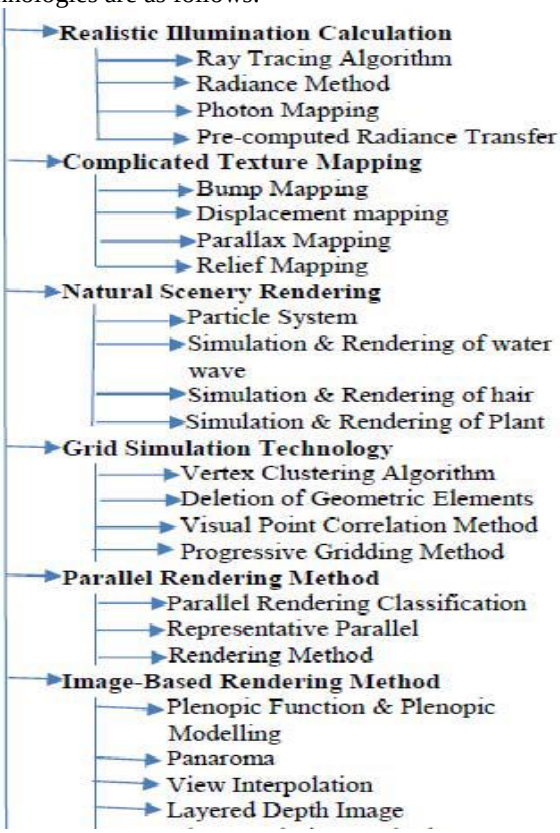

Fig. 5

V. VR INTERACTION TOOLS, EQUIPMENTS & SUPPORTING ENVIRONMENT

In this section, a description of various interaction modes & devices, modeling tools & rendering tools used in simulation of virtual/real world & immersion in virtual world are provided.

A. VR INTERACTION MODES & EQUIPMENTS

This section contains the development methods of human machine interaction techniques based on VR system requirements & applications.

❖ *Scene Display Mode & Equipment*

Head Mounted Display: A head-mounted display is a display device, worn on the head or as part of a helmet, that has a small display optic in front of one (monocular HMD) or each eye (binocular HMD). A HMD has many uses, including in gaming, aviation, engineering, and medicine lift. A head-mounted display is the primary component of virtual reality headsets. There is also an optical head-mounted display (OHMD), which is a wearable display that can reflect projected images and allows a user to see through it. There are two types of HMD: (i) Monocular HMD (ii) Binocular HMD.[3]

Desktop display: In this system, the projection of scene of virtual environment is displayed on horizontally placed display device. Desktop display system consists of mainly three parts i.e. workbench, a projector and a computer. The workbench consists of reflector & desktop display. Projector projects the scene generated by computer onto the reflector and further reflector reflects it onto display screen or monitor to represent 3D virtual objects & interfaces. By wearing stereo glasses, multi users can sense 3D scenes in virtual environment & tracking device of desktop display system provides position & direction of user's viewpoint.

Projection Display: A CAVE is typically a video theatre situated within a larger room. The walls of a CAVE are typically made up of rear-projection screens, however flat panel displays are becoming more common. The floor can be a downward-projection screen, a bottom projected screen or a flat panel display. The projection systems are very high-resolution due to the near distance viewing which requires very small pixel sizes to retain the illusion of reality. The user wears 3D glasses inside the CAVE to see 3D graphics generated by the CAVE.

Hand held display: Personal Digital Assistants (PDAs) and Smartphones have obtained huge ability in computation, storage & transmission etc. with the development of highly capable computing devices & wireless network technologies. For example, Various APIs like OpenGL ES (GLES) API for embedded systems, 3D graphics library of mobile computer system & embedded computer system, Direct3D to create 3d graphical interface of mobile computer system, Mobile 3D graphics (M3G) API, etc. enable mobile computing device to display 3D scene in virtual surroundings.[2] It supports multi interactions such as speech & text recognition, GPS location etc.

Automatic Stereo Display: It allows the user to experience the stereo effects of virtual scenes. A user can experience automatic stereo 3D virtual scenes in a 360^{o} range across the display. The user can also operate 3D virtual scenes represented by automatic stereo display through interaction device.

❖ *Force/Tactility Interaction modes & equipment*

Force feedback joystick: Joystick is a sensing device with a force feedback component which shows response of user's operations enabling them to interact in virtual environment. As per force feedback the joystick, interaction freedoms & accuracies varies from one another.

Tactility Data Gloves: Data gloves are used for tactile sensing & motion control in VR. It allows to get palm and fingers information on position, direction & gesture for controlling the motion & sensing objects. Data gloves are built of lightweight elastic material such as optical fiber which ca be easily installed as a sensor.

❖ *Tracking Location mode & equipment*

To track 3D spatial location in VR environment, a tracking device named Tracking localizer is used. It provides the location of all the equipment such as HMD, stereo glasses & data gloves etc. There are two modes of location tracking methods: active tracking location mode & passive tracking location mode.

B. VR DVELOPMENT SUITES & SUPPORT ENVIRONMENT

This section contains various development tools that lower the threshold & increase efficiency of development of VR applications.

❖ *Modelling Tools*

Animation oriented modeling tools: Various animation tools are Maya (developed in 2006), Softimage XSL, 3D studio Max (developed in 2002), Lightwave 3D etc. But, the advanced modeling tools are Maya & Softimage XSL.

Real-time rendering-oriented modeling tools: Various real-time rendering modeling tools are MultiGen Creator developed by MultiGen-Paradigm Company, Creator Terrain Studio, Terra Vista, OpenFlight etc.[4]

Web 3D standard modeling tools: Virtual Reality Markup Language(VRML) is an initial Web 3D standard. VRML97 enables 3D model files delivery in internet. VRML was renamed as Web 3D Consortium in 1998. Also, an extensible

3D (X3D) standard was introduced which was issued in 2002 & certified in August 2004 by ISO/IEC 19775 international standard. Various image-based modeling tools for web applications are Canoma, Image-Modeler, Photo3D etc.

❖ *Rendering tools*

Basic 3D graphics rendering tool: These rendering tools provide basic APIs for 3D graphics rendering. Basic 3D graphics rendering tools are OpenGL, Java3D & Direct 3D.[5]

3D graphics engine: It provides a complete software development support in organizing data, processing 3D graphics rendering, Modeling etc. & also provides a hardware support in rendering graphics applications. Various 3D graphics rendering tools are OpenGL, Open GVS, WTK, Vega etc.

Visualization development suites: These suites are used in 3D prototype system creation. Various Visualization development suites are Virtools Dev (developed by Dassault Company, France), EON Studio (developed by EON company), and Quest 3D (developed by Act 3D Company). Some game development companies like Unity3D has similar features.

VI. APPLICATIONS OF VIRTUAL REALITY

The main objective of VR is to "Replace actuality with Virtual environment" and "Replace actual test with scientific calculation".[6] The various applications of VR are:

Virtual Reality in the military- This is particularly beneficial to train soldiers for combat situations and other dangerous surroundings. They can learn how to react in a suitable manner in different dangerous conditions. Military uses of virtual reality includes flight simulation, battlefield simulation, Vehicle simulation, Medic training (battlefield) etc. Virtual Reality in education-. VR promotes students to interact with one another in a 3D virtual environment. It makes an easy to learn & fun based study without any mental pressure. Students can interact in collaboration to achieve any certain goal without any physical presence in classroom.

Virtual Reality in healthcare- VR in medical field allows medical professionals to learn new techniques & skills in a safe environment without causing any danger to the patients. In medical field, Phobia treatment using VR technology is a great interest now a day. Healthcare is one of the biggest adopters of VR that consists of surgery simulation, robotic surgery, phobia treatment and skill enhancement training.

Virtual Reality in entertainment- The VR entertainment industry promotes the development of games and many virtual worlds which provide great experience to users. Development of virtual museums, e.g. interactive exhibitions, virtual theme parks, galleries, discovery centers, theatre etc. Virtual Reality in fashion- VR in fashion industries contain VR software to construct 3D avatars & virtual fashion stores for clothes designing, 3D fashion portfolio, & fashion show in Second Life, etc.

Virtual Reality in heritage- Use of VR in museums & historical settings such as visitor centers employ interaction with public in new and exciting ways. Examples of virtual heritage sites include monuments, sculptures, caves, historical buildings, stones, archaeological digs, old towns and villages etc. Virtual Reality in business- VR used by the business community include virtual tour of a business environment, a 360 view of a product & training of new employees etc. It is very cost-effective way for developing a product or service because it enables testing of prototype before development of several version of that product or service.

Virtual Reality in engineering- VR engineering contains 3D modeling tools & visualization techniques for designing any process or product. This technology enables engineers to view their project in 3D and gain a greater understanding of working. Any flaws or risks can be depicted before implementation. This also allows the design team to make changes as, when and where necessary. The important thing is the ability of virtual reality to depict fine grained details of an engineering product to maintain the illusion. It means high end graphics, video with a fast refresh rate and realistic sound and movement.

Virtual Reality in Media- VR has been featured in various television programs & films. Various VR inspiring films are The Lawnmower Man, The Matrix, Vanilla Sky, Tron (1982 version), The Thirteenth Floor etc. There are also television programs such as selected episodes of Doctor Who, Red Dwarf and Star Trek: The Next Generation which utilize virtual reality technology.

VII. CONCLUSION

Virtual Reality is arguably the next footstep towards a modern/post-modern era of development. The potential ground-breaking effects that loom behind these machines is uncanny. With the ability to save lives, act as a medium for business development and confrontations, and provide its users with endless hours of entertainment, learning, and discovery, the world should be pushing for an increased presence of this product.

The 3D virtual developers & researchers are consistently working in developing the core standards of VR. Telepresence, 3D interaction in virtual world as avatars, cloud-based VR etc. are attracting a huge interest of researchers. These techniques are becoming more common & acceptable to various industries & organizations in recent. Cloud-based VR has become a profound interest of

researchers & developers now a day. Virtual Reality programs as Second Life & Active Worlds show the possibility to share the virtual world designs over the internet. There are too many VR programs such as 3DVIA, Google Earth, VR-Cloud, EON Creator, ZSpace, Lecture VR etc. those provide tools for coordinating & communicating on design of cloud-based VR models. Various phases have been developed to investigate the potential cloud-based VR technologies. First phase is VR representation that involves the differences in the SaaS implemented by the various tools. The second phase is VR communication that involves the communication mechanism in multi-user environment of virtual application.

ACKNOWLEDGMENT

We would like to take this opportunity and express our sincere gratitude towards Prof. Swati Gajbhiye for her guidance when required. We appreciate her valuable suggestions and support. We are also very grateful to Prof. Swati Nadkarni, Head of Department, Information Technology, Shah & Anchor Kutchhi Engineering College, Mumbai for her tremendous support and guidance.

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