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Virtual Reality – Opportunities and Challenges

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Abstract - *In today's world , we are surrounded by blends of technologies. We have acquired majorities of these technologies into our everyday lives. Increasingly, these various technologies are getting integrated to provide us with new abilities and services. And most often a computer is the heart of such integration. This is the case with Virtual Reality a so called technology which actually is a very sophisticated integration of a number of techno-logies.*

Virtual Reality is a technology based on computer which assimilates specialized input and output devices by allowing the user to interact with and experience an artificial created environment as if they were in the real world. A virtual reality system is also allowing the user to search and interact with a three dimensional virtual or artificial environment created by the designer. In the virtual world , the user can do all things similar to routine as throwing a tennis ball or as excellent as flying through space. And all these things can be made to occur only because of a hand gesture or a nod.

Virtual Reality is a three dimensional computer based interactive environment which simulate reality. Virtual Reality can bring us into a imaginary world which appears exactly similar to our own world. For designing a virtual reality system , one have to deals with ideas of spatial relationships and computer graphics which in turn are affiliated to mathematics , physics , arts and also human psychology. In these virtual or synthetic environ-ments , one have to take into account various physics laws like gravity , air resistance , and speed etc.

Keywords*: *Virtual Reality, Computer based technology, Virtual Environment, Artificial Environment, Second life, Augmented Reality.

1. INTRODUCTION

Virtual Reality (VR) technology is becoming more perfect and immerging with the aid of computer hardware, software and virtual world integration technology, which can show the real world dynamically. These technologies can make reaction according to people's form , language and so on immediately after a real time communication is formed between people and virtual world. Hence , for past few years such technology has catch up much attention of researchers and companies.

Virtual Reality (VR) can be defined as use of computer modelling & simulations which help a person in interacting with artificial 3D enviro-nment. This 3D artificial environment shows reality with help of some interactive devices which can send and receive information and are worn in form of goggles, headsets, gloves or body suits etc. In other words , virtual reality can be defined as use of computer graphics to simulate presence physically in artificial or virtual environment & to create a realistic looking world. Virtual Reality is a real time and interactive technology ; which means that the computer is developed to automatically detect inputs given by user and can modify instan-taneously the virtual world.

Most newer virtual reality environment are visual experiences which are displayed either on a computer screen or projector ; but some simulations may also require additional sensory information like speakers or headphones. Some-times , users can also make interaction with a virtual environment either by use of standard input devices such as a keyboard, mouse etc.

In practice, it is very difficult currently to get a high experience of virtual reality mostly because of technical limitations on processing power & image resolutions. However, those limitations are expected to eventually be overcomed by use of more powerful , cost effective processor and imaging technologies over time.

2. LITERATURE REVIEW

Bharath et al.[1] presented their paper on "Importance & Applications of Virtual Reality in Engineering sector". In this paper; Virtual reality is defined as an immerging technology that can provides capability to realize actual working environment . Further, discussions are made on approaches needed to realize virtual reality. Paper also explores importance and usage of virtual reality in engineering sector like design , manufacturing , insp-ection , tooling , assembly , prototyping etc . Moreover ; benefits , costs , limitations and risks associated while adopting VR are also covered and highlighted.

Radharamanan et al.[2] represented their paper on "A survey of virtual reality technologies , it's applications and limitations". In this paper various technologies that are used for virtual reality are highlighted like Head Mounted Display (HMD) , Caves , Hand Gloves, 3D Mouse, Space ball, Full body suits, Video camera and sensor etc. In addition ; technical aspects of virtual reality techno-logies are also covered. At last advantages & limitations of using virtual reality in present and for future are also summarized.

3. NEED OF VIRTUAL REALITY

Due to increasing advancement in technologies & to fulfill growing need of customers ; Virtual reality is now a day's consider most immerging and efficient techno-logies which has not only overcomed limitations of augmented reality but also made human life simpler and easier. Some of the growing needs of virtual reality are as follows :

1) Simulate the real world dynamically by use of computer software , hardware and virtual world integration technologies.
2) Can pretend to have physical presence in places in the real world as well as in imaginary worlds.
3) Without any real danger ; we can be part of the action on the virtual safe environment.
4) Virtual reality can help us to visualize working environment where people cannot go especially mars or low temperature environment by making same atmospheric conditions by use of computer graphics software and use of headsets , gloves etc & make them feel same physical presence.

Fig - 1: Use of virtual reality technology (HMD) for gaming purpose[1]

Fig - 2: Need of virtual reality technology (Oculus Rift CV1) for training[2]

4. WORKING PRINCIPLE OF VIRTUAL REALITY

The Virtual Reality system works on the following principle :

- It first tracks the physical movements in the real world , then a computer redraws the virtual world to reflect those movements. The updated virtual world is sent to the out-put (to the user in the real world).
- In this case , the output is sent back to a head mounted display. Hence, the user feels "immersed" in the virtual world as if they are in the virtual world itself as all they can watch is their rendered movements in virtual environment.

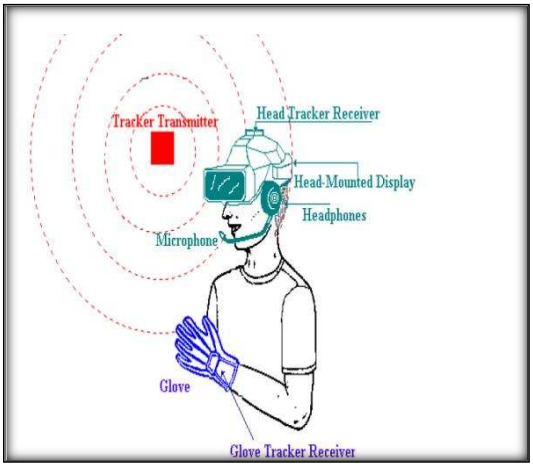

Fig - 3 : Virtual Reality hardware structure

5. TYPES OF VIRTUAL REALITY

There are many types of Virtual Reality, considering the following :

- Enhanced Virtual Reality
- Immersive Virtual Reality
- Quick Time Virtual Reality
- Immersive Virtual Reality
- Desktop Virtual Reality
- Hybrid Virtual Reality

5.1 Immersive Virtual reality

- An immersive system replaces our real world view with the images generated by computer that interact to the position and orientation of the user's head.
- Headed Mounted Display (HMD) can be used to see such environment.
- In a completely immersive system , the user actu-ally feels part of the environment (experiences a feeling of presence).
- Here, the user has no visual contact with the physical world.

Fig - 4 : Immersive virtual reality[5]

5.2 Non Immersive Virtual reality

- On the other hand , non immersive system leaves the user visually aware of the real world but able to observe the virtual world through some display device like graphics workstation etc. It is also called as semi immersive system.

- Advanced flight, ship & vehicle simulators are semi immersive type of virtual reality. The cockpit, bridge or driving seat is a physical model, where as the view of the world outside is computer-generated (typically projected).

Fig - 5 : Non Immersive virtual reality[6]

Fig - 6 : Non Immersive virtual reality

5.3 Hybrid Virtual reality

- It allows the user to see the real world with virtual images superimposed over this view.

- Such systems are also called as “Aug-mented virtual reality systems”.

Fig - 7 : Hybrid virtual reality[6]

Fig - 8 : Hybrid virtual reality[6]

6. ARCHITECTURE FOR VIRTUAL REALITY

Main components present in architecture of virtual reality are:

- Kernel system
- Simulation
- Driver Software packages
- Audio Devices
- Visual Output devices
- Interaction devices
- Tracking Devices
- Speaker
- Head phones

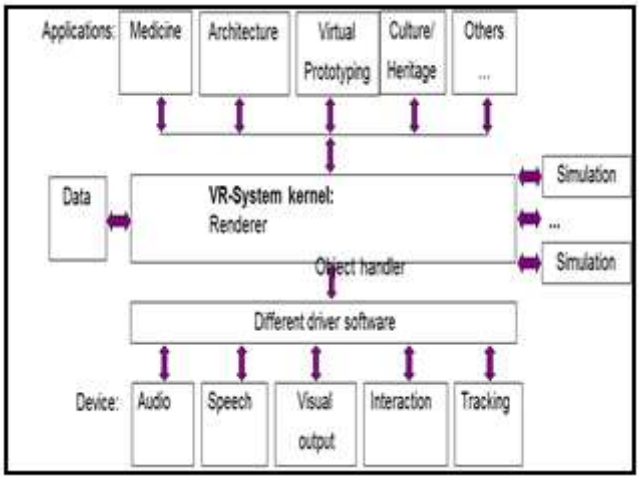

Fig - 9 : Architecture for virtual reality[1]

7. TECHNICAL ASPECTS OF VR

Various technical aspects of virtual reality technologies are:

- Input Process
- Simulation Process
- Rendering Process

7.1 Input Process

- This process controls the input devices like keyboard , joystick , 3D position trackers (glove , wand , body suit) , voice recognition system etc. Some glove sys-tems can also add gesture recognition.
- The objective is to get the coordinated data from the input devices to the rest of the system.

7.2 Simulation Process

- This process is the core of a virtual reality program . It can handle the interactions , simulation of physical laws & determines the world status.
- It is a discrete process which is iterated once for each time step or frame. This process can finally decide what actions to be taken place in the virtual world.

7.3 Rendering Process

- This process creates sensations which are output data to the user or other network processes.
- There are separate rendering processes like:
  - Visual Rendering
  - Auditory Rendering
  - Haptic Rendering

7.3.1 Visual Rendering

- Visual Rendering is related to the computer graphics & animations. This process is also referred to as render-ing pipeline process.
- It consists of a series of sub processes that are involved to generate each frame.
- It begins with information of the world , the objects , lighting & camera (eye) location in the world space.
- The objects get their geometries transformed into the eye coordinate system. Then, the algorithms & actual pixel rendering is done.

7.3.2 Auditory Rendering

- Auditory Rendering generates mono, stereo or 3D audio.
- There are many aspects of our head & ear shape that affect the recognition of 3D sound. Hence , the HRTF is app-lied to the sound.

7.3.3 Haptic Rendering

- This haptic rendering area is newly growing science & there is much more to be learned in such rendering.
- Haptics is the generation of touch & force feedback information. Almost all systems today are focusing to have force feedback.

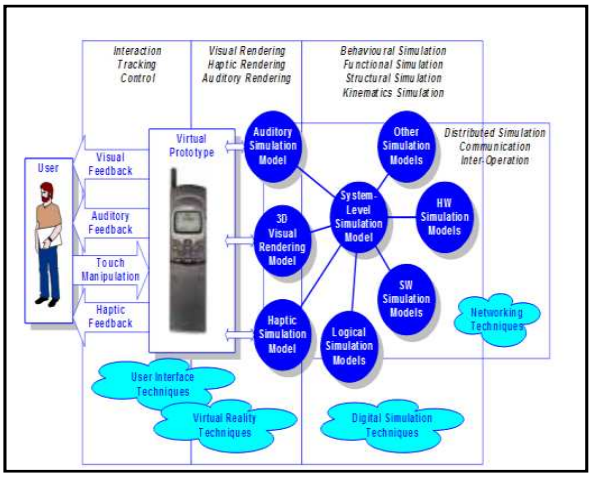

Fig - 10 : Human-Computer interaction with virtual prototypes[3]

8. DEVICES USED FOR VR TECHNOLOGIES

Devices that are used for virtual reality are as follows :

- Head Mounted Display
- Cave
- Gloves
- 3D Mouse
- Space Ball
- Video camera and shadows
- Voice recognition
- Biological sensors
- Full body suits

8.1 Head Mounted Display (HMD)

- HMD is a device similar to helmet or a face mark that holds the visual and auditory displays. In HMD, projector ray's feeds real time images to small screens attached inside helmet that the user wears.

- HMD device consist of two small miniature display screens and a optical system. These two components takes the images from the screens to the eyes, presenting a stereoscopic imaging. Others use a single larger display to provide higher resolution, but without the stereoscopic vision.

- HMD provides virtual images by continu-ously tracking the position and orientation of the user`s head. This allows viewer to look around and walk through the surrounding virtual environment. How-ever, HMDs have cables which restrict our movement.

Fig - 11 : Head Mounted Display (HMD)

8.2 CAVE

- The Cave Automatic Virtual Environment (CAVE) is an immersive virtual reality facility designed for the exploration of and interaction with spatially engaging environments.

- Basically, the CAVE's comprises of four projection surfaces on which images are projected with uniquely immersive design.

- In addition , including projection on the ceiling gives a fuller sense of being enclosed in the virtual world.

- Furthermore, projection on all six surfaces of a room allows users to turn around and look in all directions. This helps user to interact with virtual environment with better sense of full immersion.

Fig - 12 : CAVE[2]

8.3 Pinch Gloves

- Pinch glove enables natural interaction with objects. It uses hand-signs to execute actions. It continuously tracks the motion of the user's hand & limb and accordingly gives signal to the trans-mitter.

Fig - 13 : Pinch Gloves[1]

8.4 3D Mouse

- A 3D mouse has two parts as vertical & horizontal part. Each part has some buttons. With different combinations of these buttons the user can produce differ-rent positions in the 3D environment.

Fig - 14 : 3D Mouse[6]

9. APPLICATIONS OF VIRTUAL REALITY

Virtual reality now a day's used in wide range of applications, some of very important area of use is as follows :

- Business
- Training
- Engineering and design
- Medical
- Entertainment
- Education and conferencing
- Architecture design and prototyping
- Competitive sports application
- Virtual Manufacturing system
- Military Applications
- Mobile and gaming applications
- Defense industry
- Ergonomics and human factor analysis
- Museum and art design
- Design Evaluation (Virtual Prototyping)
- Planning & Maintenance
- Concept & Data visualization
- Sales & Marketing
- Operations in hazardous environments
- Entertainment , Leisure etc

9.1 Business

- Virtual reality is being used in a number of ways by the business community which include:
  - Virtual tours of a business environment
  - Training of new employees.
  - A 360 Degree view of any product.

Fig - 15 : Business[2]

9.2 Training and Simulation

- Virtual reality environments have been used for training simulators.
- The usage of VR in a training perspective is to allow professional conduct training in a virtual environment where they can improve upon their skills without the consequence of failing the operation.
- Examples include flight simulators, battlefield simulators for soldiers, paratrooping, combat training for the military.

Fig - 16 : Training & Simulation[1]

9.3 Engineering and Design

- Virtual Reality is most popularly used in engineering and designing process.
- It gives better understanding of the design and help to facilitate changes wherever necessary.
- It helps to reduce the time and cost factor.
- Examples are building construction, car designing etc.

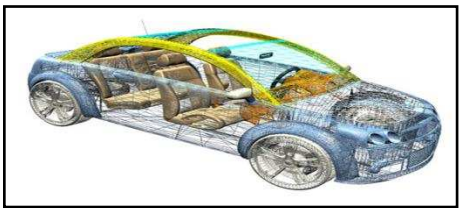

Fig - 17 : Engineering & Design[4]

9.4 Entertainment

- The entertainment industry is one of the most enthusiastic advocates of virtual reality, most noticeably in games and virtual worlds.
- An example includes virtual museum, gaming , virtual theme parks , inter-active exhibitions etc.

Fig - 18 : Entertainment[5]

9.5 Education and Conferencing

- Education is another area where virtual reality has been adopted for teaching and learning situations.
- The advantage of this is that it enables large groups of students to interact with each other as well as within a three dimensional environment.
- It is able to present complex data in an accessible way to students which is both easy to learn and fun.
- Plus these students can interact with the objects in that environment in order to discover more about them.
- Best example where virtual reality can be more useful is for medical students to develop surgery simulations or 3D images of human body where students can explore nicely without danger. This type of technology is mostly used in UK and abroad.

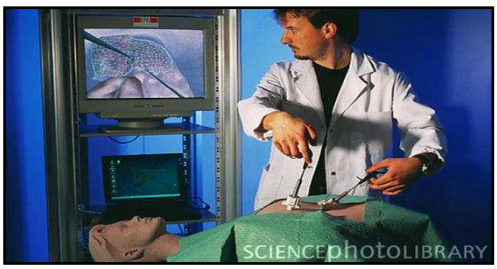

Fig - 19 : Education[1]

9.6 Digital Prototyping

- Digital prototyping is also popular area of research where virtual reality is widely used now a day's.

Fig - 20 : Digital Prototyping[6]

9.7 Assembly Verification

- After assembly of component is done , to verify whether components are proper-ly assembled of not virtual reality and digital prototyping is used.

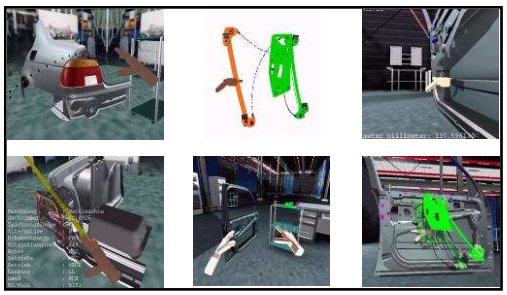

Fig - 21 : Assembly Verification[4]

9.8 Inspection

- Virtual inspection makes use of the VR technology to simulate the inspection process, and the physical properties of the inspection equipment.
- Its purpose is to study inspection methodologies, collision detection, ins-pection plans , factor affecting the accu-racy of inspection process.

9.9 Layout Planning

- Facility layout design has long been recognized as one of the most critical and difficult design tasks in manufacturing industries. It may affect many other important operational characteristics like throughput time, production volumes, quality, cost and employee morale.
- Traditional layout methods that provide the user with a two-dimensional (2D) view of the facility cannot fully solve the complex spatial layout problems. Due to the requirement of a smarter factory planning , VR can be a useful tool to improve the understanding of the plans and to support interdisciplinary discussions.
- Virtual environment provide a visual, three dimensional space in which a user can explore the space requirement, storage area , office spaces and various clearances before building the actual factory.

9.10 Machining

- Virtual machining mainly deals with cutting processes, such as turning, milling , drilling and grinding etc.
- In the virtual environment, a user can mount a work piece on the milling machine , choose a tool and perform direct machining operations such as axial movements or predefined seque-nces.
- The VM technology is used to study the factors affecting the quality, machining time of the material

removal process as well as the relative motion between the tool and the workpiece.

10. CHALLENGES

Like many advantageous technologies ; besides opportunities , applications , sec-ond life , there always exist unavoidable challenges and disadvantages too . In fact use of virtual reality technologies offer both technical and cultural challenges. We can try our level best to minimize this challenges rather than trying to completely avoid it. Reasons of these unavoidable challenges are:

10.1 Technical Challenges

- All features or functions of virtual environment can only be streamed by streaming all data to the user live over the Internet with minimal local caching of frequently used data. This means that user must have a minimum of 300kbit/s of Internet bandwidth for basic functionality, and 1Mbit/s for getting better performance.

- Due to the proprietary commun-ications protocols , it is impossible to make use of a network proxy or caching service to minimize network load when many people are all using the same location. **For ex :** when used for group activities in company or schools.

- Cost is another challenging issues ; as these technologies are newer , they are more costlier due to which many small/medium scaled people can't afford it.

- As technologies are growing at rapid rate, many people are still unaware of such new technologies , along with its advantages , disadvantages and applications. Hence awareness has to be created among the people by conducting free seminars and demonstration.

- In addition to appropriate internet bandwidth and interfacing charges, there are several membership charges too. **For ex :** For virtual learning, premium account is necessary to purchase land and to create sustained and safe learning environment for the students.

- High powerful computer systems or computer systems having high powerful processor are required for creating proper virtual environment.

10.2 Cultural Challenges

- Liability issues are still question in virtual world. As we know that private land need to be purchased for virtual learning and this private land are restricted to only authorized users. However users in public area may have to suffer violence or disruptiveness.

- There are many unsolved legal issues surrounding like virtual violence, sexual harassment , virtual assault .

- Everyday billions of people connect in these worlds to socialize , shop and learn. Unfortunately, many laws breaker also joined this virtual world and many criminal activities are taking placed. common criminal cases which are occurring everyday are money laundering , sexual harassment , exchanging of child abuse environment and terrorist attack etc.

- Inventory loss issues is still present ; inventory loss in which items in users inventory including those things which have been paid for can disappear without warning or enter a state where they will fail to enter in a world when requested (Giving an " object is missing " database error). This loss is although much less in past years, but still it's existing.

11. CONCLUSION

- Virtual Reality future depends on the existence of systems that address problems of 'large scale' virtual enviro-nments.

- In the coming years, as more research is done we are bound to see VR become as main stay in our homes and at work. As the computers become faster, they will be able to create more realistic graphic images to simulate reality better. It will be interesting to see how it enhances artificial reality in the years to come.

- It may also be possible that in the future we will be communicating with virtual phones. Nippon Telephone and Tele-graph (NTT) in Japan are developing a system which will allow one person to see a 3D image of the other using VR techniques. So, the future is in virtual reality and its benefits will also remain immeasurable.

- More and more research has shown its necessity both from evolutionary and revolutionary perspective for providing better user interference and enabling previously impossible application.

- Applications area which are benefitted by use of virtual reality technologies are medical , design , engineering , inspec-tion , assembly , entertainment etc.

- Hence, Virtual reality has thus finally begun to shift away from the purely theoretical towards practical knowl-edge.

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