# Virtual Reality
# Technology, Applications and Future

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**Abstract:**
**VirtualReality(VR),sometimes called Virtual Environments (VE) has drawn much attention in the last few years. Extensive media coverage causes this interest to grow rapidly. Very few people, however, really know what VR is, what its basic principles and its open problems are. In this paper a overview of virtual reality is presented, basic terminology and classes of VR systems are listed, followed by applications of this technology in science, work, and entertainment areas. An insightful study of typical VR systems is done. All components of VR application and interrelations between them are thoroughly examined: input devices, output devices and software. Additionally human factors and their implication on the design issues of VE are discussed.**

**Keywords:** Virtual environment**,**Perception,Immersion, Simulation,Illusion.

## 1. INTRODUCTION:

### A. Scope of the project:

**Virtual Reality** is something that allows everyone to experience the impossible. **Virtual Reality** is the term used to describe a three-dimensional,computer generated environment which can be explored and interacted by a person.

### B. Need of the project:

Virtual reality is in its experimental stage today, but without doubt it has a great potential to alter our life. People expect very much from this technology Therefore, virtual reality plays a very important role in every field today. It became a perfect tool for architects, designers, physicists, chemists, doctors, surgeons etc.

### C. Basic definition:

Virtual reality otherwise called as artificial reality is generally defined as the computer-generated simulation of a three-dimensional image or environment that can be interacted with a seemingly real or physical way by a person using special electronic equipments .

### D. Terminologies:

• **Telepresence** – is a specific kind of virtual reality that simulates a real but remote (in terms of distance or scale) environment.

• **Cyberspace** – was invented and defined by William Gibson as "a consensual hallucination experienced daily by billions of legitimate operators (...) a graphics representation of data abstracted from the banks of every computer in human system"

### E. Levels of immersions in virtual reality system:

• **Desktop VR** – sometimes called Window on World (WoW) systems It uses a conventional monitor to display the image (generally monoscopic) of the world. No other sensory output is supported.

• **Fish Tank VR** – improved version of Desktop VR. These systems support head tracking and therefore improve the feeling of "of being there" .They still use conventional monitor for stereoscopic viewing.

• **Immersive systems** – the ultimate version of VR systems. They let the user totally immerse in computer generated world with the help of HMD that supports stereoscopic view of the scene accordingly to the user's position and orientation.

## 2. VIRTUAL REALITY TECHNOLOGY:

### 2.1. A first look at VR applications: basic components

VR requires more resources than standard desktop systems do. Additional input and output hardware devices and special drivers for them are needed for enhanced user interaction. But we have to keep in mind that extra hardware will not create an immersive VR system. Special considerations by making a project of such systems and special software are also required. First, let us have a short look at the basic components of VR immersive applications.

#### 2.1.1. Input devices

Input devices determine the way a user communicates with the computer. Ideally all these devices together, should make user's environment control as intuitive and natural as possible – they should be practically invisible. Unfortunately, the current state of technology is not advanced enough to support this, so naturalness may be reached in some very limited cases.

In most of cases we still have to introduce some interaction metaphors that may become a difficulty for an unskilled user.

#### 2.1.2. Output devices

Output devices are responsible for the presentation of the virtual environment and its phenomena to the user – they contribute to the generation of an immersive feeling at most. These include visual, auditory or haptic displays. As it is the case with input, the output devices are also underdeveloped. The current state of technology does not allow to stimulate human senses in a perfect manner, because VR output devices are far from ideal: they are heavy, lowquality and low-resolution. In fact most systems support visual feedback, and only some of them enhance it by audio or haptic information.

#### 2.1.3. Software

Beyond input and output hardware, the underlying software plays a very important role. It is responsible for the managing of I/O devices, analyzing incoming data and generating proper feedback. The difference to conventional systems is that VR devices are much more complicated than these used at the desktop – they require extremely precise handling and send large quantities of data to the system. Moreover, the whole application is time-critical and software must manage it: input data must be handled timely and the system response that is sent to the output displays must be prompt in order not to destroy the feeling of immersion.

### 2.2. Human factors

As virtual environments are supposed to simulate the real world, by constructing them we must have knowledge how to "fool the user's senses". This problem is not a trivial task and the sufficiently good solution has not yet been found: on the one hand we must give the user a good feeling of being immersed, and on the other hand this solution must be feasible.Which senses are most significant, what are the most important stimuli and of what quality do they have to be in order to be accepted by the user? Let us start by examining the contribution of each of the five human senses:

• sight................. 70 %
• hearing.............. 20 %
• smell ..................5 %
• touch..................4 %
• taste ...................1 %

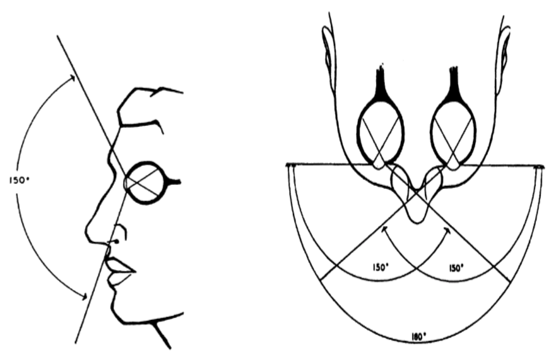
This chart shows clearly that human vision provides the most of information passed to our brain
and captures most of our attention. Therefore the stimulation of the visual system plays a principal role in “fooling the senses” and has become the focus of research.

**2.2.1. Visual perception characterization**

As already mentioned before, visual information is the most important aspect in creating the illusion of immersion in a virtual world. Ideally we should be able to generate feedback equal to or exceeding the limits of the human visual system .

**Field of view:**

The human eye has both vertical and horizontal field of view (FOV) of approximately 180° by 180°. The vertical range is limited by cheeks and eyebrows to about 150°. The horizontal field of view is also limited, and equals to 150°: 60° towards the nose and 90° to the side. This gives 180° of total horizontal viewing range with a 120° binocular overlap, when focused at infinity.




**fig(a)** **fig(b)**

**Figure 2.2.1.1.** Human field of view: (a) vertical,
(b) horizontal

**Visual acuity:**

Visual acuity is defined as the sharpness of viewing. It is measured as the fraction of a pixel which spans one minute of arc horizontally . Acuity changes for the different arc distances from the line of sight. For the objects that are reasonably lighted and lie on-axis (and therefore are projected onto the fovea – the part of retina that can resolve finest details in the image acuity is the best: the eye can resolve a separation of one minute of arc. therefore are projected onto the fovea – the part of retina that can resolve finest details in the image acuity is the best the eye can resolve a separation of one minute of arc.

**Temporal resolution:**

Temporal resolution of the eye refers to the flickering phenomena perceived by humans, when watching a screen (e.g., CRT) that is updated by repeated impulses. Too low refresh rates, especially for higher luminance and big displays, causes the perception of flickering. To avoid this bad effect, a higher than the critical fusion frequency screen refresh rate (15Hz for small screens and low illumination levels to 50Hz for big screens and high illumination levels) must be used.

**Luminance and color:**

The human eye has a dynamic range of ten orders of magnitude which is far more than any current available display can support. Moreover, none of the monitors can cover the whole color gamut. Therefore special color mapping techniques must be used to achieve possibly the best picture quality.

**Depth perception:**

To generate depth information and stereoscopic images the brain extracts information from the pictures the eyes see and from the actual state of the eyes. This bits of information are called depth cues. All of the depth cues may be divided into two groups: physiological (like accommodation, convergence or stereopsis) and psychological (like overlap, object size, motion parallax, linear perspective, texture gradient or height in visual field).

**2.2.2. Simulator sickness**

There are potentially many sources of simulator sickness. Hardware imperfection may contribute to the generation of sickness feeling, because it fails to provide perfect stimuli to human senses.

**Latency and synchronization:**

The success of immersive applications depends not only on the quality of images but also on the naturalness of the simulation. Desirable property of an intrinsic simulation is prompt, fluent and synchronized response of the system. The main component of latency is produced by rendering , consequently frame update rates have the biggest effect on the sense of presence and efficiency of performed tasks in . Low latencies (below 100ms) have little effect on performance of flight simulators and frame rates of 15Hz seem to be sufficient to fulfill the sense of presence in virtual environments Nevertheless higher values (up to 60Hz) are preferred, when performing fast movements or when perfect registration (e.g., in augmented reality) is required.

**2.3. VR input devices**

**2.3.1. Position and orientation tracking devices:**

**a. Magnetic trackers**

Magnetic trackers are the most often used tracking devices in immersive applications.


**fig(c)**

**Figure 2.3.1.1.** Emitter and receiver units of Polhemus Fastrak.

They typically consist of: a static part (emitter, sometimes called a source), a number of movable parts (receivers, sometimes called sensors), and a control station unit. The assembly of emitter and receiver is very similar: they both consist of three mutually perpendicular antennae. As the antennae of the emitter are provided with current, they generate magnetic fields that are picked up by the antennae of the receiver. The receiver sends its measurements (nine values) to the control unit that calculates position and orientation of the given sensor. There are two kinds of magnetic trackers that use either alternating current (AC) or direct current (DC) to generate magnetic fields as the communication medium.

**b. Acoustic (ultrasonic) trackers**

Acoustic trackers use ultrasonic waves (above 20kHz) for determining the position and orientation of object in space. As the use of sound allows the determination of relative distance between two points only, multiple emitters (typically three) and multiple receivers (typically three) with known geometry are used to acquire a set of distances to calculate position and orientation.

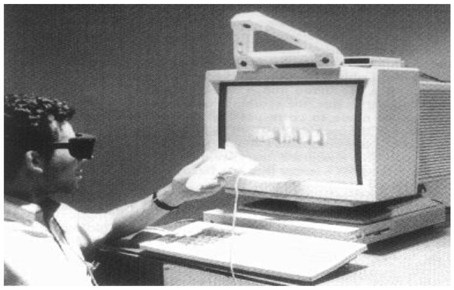


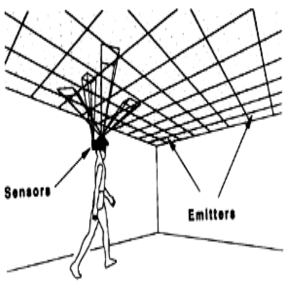
**fig (d)**

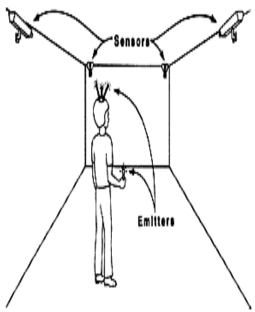
**Figure 2.3.1.2.** Logitech 6DOF Ultrasonic Tracker

**c. Optical trackers**

These systems transmit onto the object the laser light that is passed through a diffraction grating. A sensor analyzes the diffraction pattern on the body's surface to calculate its position and orientation.

• high update rates up to 240Hz – in most of cases limited only by the speed of
the controlling computer.
• possibility of the extension to the large working volumes
• not sensible to the presence of metallic objects.




**fig(e)** **fig(f)**

**Figure 2.3.1.3.** Beacon trackers: (a) outside-in and (b) inside-out tracking paradigms

**2.3.2. Eye tracking**

One more important aspect can be taken into account: the visual acuity of the eye changes with the arc distance from the line-of-sight. It means that image does not need to have equal resolution and quality over the whole display area. Objects that lie far the line-of-sight can be represented coarsely, because the user will not notice it. Consequently, this may lead to the dramatically decrease of rendering costs.Therefore eye-tracking techniques may be incorporated to determine the direction.

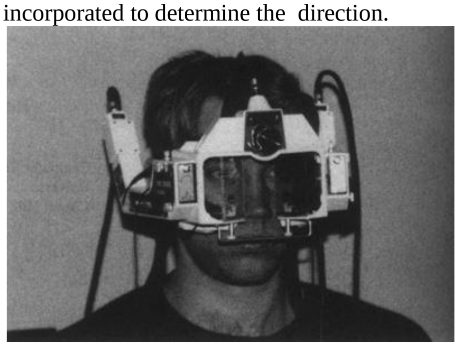


**fig (g)**

**Figure 2.3.2.1.** NAC Eye Mark eye tracker

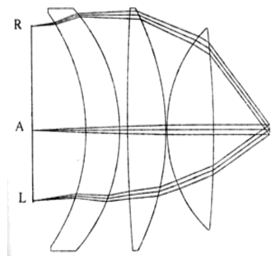
**corneal reflection** – uses photo-transistors to analyze a reflection of collimated beam of light from the convex cornea surface. This approach offers relatively good accuracy (0.5° to 1°), but it needs complex calibration, covers relatively small eye-movement area and is sensitive to variations in cornea shape variations, tear fluids and corneal astigmatism.

**2.4. VR output devices**
**2.4.1. Visual displays**
**Technology**

Two display technologies are currently available. They are:

• **CRT** – cathode ray tube displays are based on conventional television technology. They offer relatively good image quality: high resolution (up to 1600x1280), sharp view and big contrast. Their disadvantages are high weight and high power consumption. They also generate high-frequency, strong magnetic fields that may be hazardous to the user's eyes and may have negative influence on the quality of measurements of magnetic trackers.

• **LCD** – liquid crystal diode displays are a relatively new technology that is alternative to standard CRT displays. LCD displays are flat, lightweight, have low power consumption and lower emissions than CRTs. The biggest disadvantage is poor image quality: low contrast, brightness and resolution (typically up to 720x480).



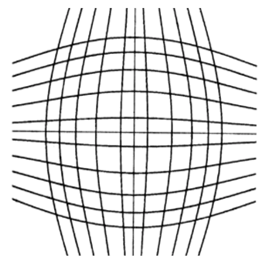



**fig (h)** **fig (i)**

**Figure 2.5.1.1.** LEEP optics: (a) tracing of rays through the LEEP optics,
(b) predistortion grid for the LEEP optics

**2.5Applications of VR**
**2.5.1. Modeling, designing and planning:**

In modeling virtual reality offers the possibility of watching in real-time and in real-space what the modeled object will look like. Just a few prominent examples: developed at the Fraunhofer Institute Virtual Design or mentioned already before Virtual Kitchen – tools for interior designers who can visualize their sketches. They can change colors, textures and positions of objects, observing instantaneously how the whole surrounding would look like.

**fig(j)**

**Figure 2.5.1.1.**Virtual Design

**2.5.2. Entertainment:**

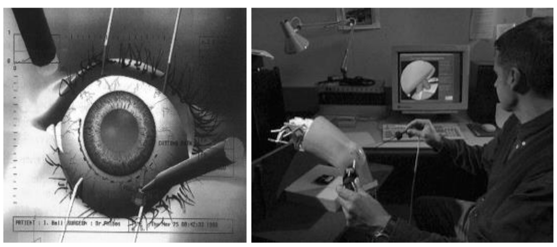
Constantly decreasing prices and constantly growing power of hardware has finally brought VR to the masses – it has found application in the entertainment. In last years W-Industry has successfully brought to the market networked multi-player game systems (see fig. 2.5.2.1). Beside these complicated installations, the market for home entertainment is rapidly expanding. Video game vendors like SEGA and Nintendo sell simple VR games, and there is also an increasing variety of low-cost PC-based VR devices. Prominent examples include the Insidetrak (a simplified PC version of the Polhemus Fastrak), i-glasses! (a low cost see-through HMD) or Mattel Power Glove.

**fig (k)**

**Figure 2.5.2.1.** VR in entertainment

**2.5.3. Training and education:**

Nowadays they are used by many civil companies as well, because they offer lower operating costs than the real aircraft flight training and they are much safer (see fig. 2.5.3.1l). In other disciplines where training is necessary, simulations have also offered big benefits. Therefore they were prosperously applied for determining the efficiency of virtual reality training of astronauts by performing hazardous tasks in the space . Another applications that allow training of medicine students in performing endosurgery , operations of the eye and of the leg were proposed in recent years (see fig. 2.5.3.1m). And finally a virtual baseball coach has a big potential to be used in training and in entertainment as well.



**fig(l)** **fig(m)**

**Figure 2.5.3.1.** VR in medicine: (m) eye surgery, (m) leg surgery

**3. THE FUTURE OF VIRTUAL REALITY:**

The future of every new technology, including virtual reality, must be considered in two different aspects: technological and social. Technological aspects include new research directions and potential use of them for scientific aims. Social aspects include the influence of new inventions on people, individuals and society as a whole.

There is need for mechanisms allowing people to easily adapt themselves and their behavior from VR to reality and vice versa. To address these requirements better than current systems do, a lot of research must be carried out and new technologies must be developed .

**Social aspects:**

Virtual reality is in its experimental stage today, but without doubt it has a great potential to alter our life. People expect very much from this technology. It can be used for good aim and becomes a perfect tool when not misused.

**3.1. Tracking technologies**

Today's tracking technologies have many limitations. First and foremost: in many cases the tracked volume is very restricted. In practice the user is bound very closely to some point in space (i.e. tracker reference point) and cannot walk around freely. Moreover, the quality of tracking is often not sufficient – most of currently used technologies are very sensitive to environmental conditions (the quality of measurement decreases dramatically with the distance) and introduce considerable latency. An ideal tracker should be small and lightweight so that it can be comfortably worn by the user. The working volume for the inside tracking should be big enough to allow free walking for example in a big room (ten by ten meters?). And at least, the tracker should be immune to any kind of interferences that would guarantee the equally high measurement precision in the whole volume.

**3.2. Computing power and rendering architectures**

Behind all virtual worlds a high computing power is hidden. It is the "engine" for the generation of all kinds of feedback presented to the user. Though the most powerful computers are used in VR, there is a continuing hunger for more MIPS and megabytes. More detailed and impressive

scenes require more storage capacity, more CPU performance and graphical power. Therefore new processors and graphics boards are being developed in order to fulfill these needs. In practice, however, standard UNIX workstations are utilized for VR applications that do not guarantee real-time operation (UNIX is not a real time system!) and VR specific requirements like constant frame-rate rendering or dynamic image registration are compromised.

**3.3. "Seamless" virtual environments**

Majority of VR research directions concentrated up to now, generally on the technical aspects. The improvement of the performance, quality and responsiveness of virtual worlds was the main problem. However, most of currently existing systems are in fact only test-beds that cannot be used in any practical application. To construct "seamless" virtual environments proper high-level software must be developed as the basis for "real" applications . To achieve this aim, following most important issues must be taken into consideration like modeling interactive worlds, distributed multi-user architectures, effective user interaction.

**3.4. Biomedical research**

Sophisticated input and output devices are some of the most expensive parts of VR systems. The development in the area of micro electronics gives a hope that new, high power "silicon architectures" will be elaborated relatively fast. On the other hand, current "standard" output and input devices are far below the satisfying quality. The improvement of them (better resolution, precision etc.) is extremely expensive mainly because it is bound by technological frontiers. To overcome these problems, biomedical signal processing could be used both for input and output. Based on biosignals measured by electrodes, muscle activity could be detected. By processing these signals, the positions of body parts could be tracked. Moreover, this approach can be used for improvement of existing motion prediction techniques (e.g., head movement). Knowing neural signal patterns that force muscle actions and knowing the head "transfer function" (i.e. how the head reacts on muscle input), one could more precisely predict the future position and orientation of the head. The output of computers can be directly connected to the human nerves.

**3.5 User interfaces**

VR means that no interface is needed: every kind of human-computer-human interaction should be so natural and intuitive that neither learning nor adaptation should be necessary. Though, we are far from this: today's interfaces are clumsy, often require heavy hardware devices, complicated calibration steps and non-intuitive interaction paradigms. Hence they are not easy to operate by the unskilled user. Future interaction with virtual worlds should involve better input and output devices. Every input device should be at the same time an output device that supports appropriate haptic feedback. This is essential, because every action performed in the real world on some object causes a reaction of this object. These cues allow humans to perform manipulation tasks without seeing what happens – our sense of touch informs us about it! Other senses must be included into the interaction process like audio output and voice recognition for verbal communication with computer and finally: taste and smell. Combination of all these sensations would widen information passing channels between computer and human and make virtual reality really realistic. Gloves with feedback, dexterous and exoskeletal manipulators (for the hand and even whole arm) are the first attempt to improve high quality haptic interfaces.An extension of them might become a force feedback suit delivering haptic sensations to the whole body. However, existing prototype devices are very complicated mechanical constructions, heavy and uncomfortable in use.

## 4. CONCLUSION

As a conclusion, we can say that given the complexity of VR, the importance of human factors, and the lack of standard solutions, the secret of successfully implementing professional VR applications is to set realistic expectations for the technology . It is common to have misconceptions on what VR can and cannot do, and to have negative reactions when noticing that VR "is not that real". As for all technologies, but more importantly for a much emphasized and complex technology such as VR, it is important to choose appropriate applications with well define functionality objectives, to compare the abilities of VR with competing technologies for reaching those objectives, to ensure that the VR solution can be integrated with standard business practices, and to choose the right set of tools and technique.

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