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ORIGINAL RESEARCH

# Virtual reality and its military utility

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**Abstract** Virtual reality (VR) is rapidly emerging as a new area of multidisciplinary research. During the last couple of years, its scope has increased beyond academic research, and industry is found making significant investments in this field both for the research as well as for the manufacture of the development of various VR-based products. Various industrial sectors such as information technology, biomedical engineering, structural designing and training aids technology sector are investing into this technology. Military industry which always remains into lookout for new ideas is slowly emerging as one of the major investors into VR. This essay presents an assessment about the relevance of VR for the militaries.

**Keywords** Virtual reality (VR) · Real world · Virtual world · Simulators · Military · Warfare

## 1 Introduction

Virtual reality (VR) is a centuries old notion. But, in yesteryears it was not articulated in the fashion the way it is done in the present era. Many generations back, the Greek philosopher Plato (427-347 B.C.) had offered a perspective to the then rulers with regard to political decision making. He had urged them to take the political decisions strictly on the basis of certain knowledge and not on intuition. To explain his argument, he had presented a metaphor in form of 'trapped prisoners in cave'. This formulation presents a view that the people who have spent their lives in cave chained, start believing the 'shadows' which they see in dark as real. Plato wanted political class to separate shadows from substance. Probably, Plato could be viewed as propounding the concept analogous to virtual reality in those times. It could be debatable whether he announced or renounced the concept of virtual reality; however, he was definitely instrumental in highlighting the visible manifestation of 'alternative' reality.

Over the years, the concept of virtual reality has evolved significantly. In particular, the important developments taking place in the field of information technology sector has revolutionized the turf of virtual reality significantly. Presently, virtual reality applications are finding utilities in various fields of life from computer sciences to mechanical engineering to biomedical engineering to medicine to architecture. Armed forces too are identifying various VR-based applications for their utilization. It appears that this technology is likely to find more utility for the armed forces in years to come. This paper attempts to analyze the efficacy of this technology for the security architectures of the states.

## 2 The idea of virtual reality

Like many other scientific discoveries, VR has its roots in science fiction novels and essays. The first experience of VR could be said to have come in 1962 with the creation of machine called Sensorama which essentially was game giving the player an experience of riding a motorcycle on

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the streets.[1] This was developed by Morton Heilig who was a cinematographer by profession. His goal was to encompass all five senses into one virtual experience. Since, then VR has made its presence felt mainly in the entertainment arena particularly for developing video games and movies.

Presently, the field of VR is growing much beyond the entertainment industry and covers a broad spectrum of ideas in the overall technology domain. Perhaps, the involving nature of this technology is making it difficult to define the VR in exact terms. It is tough to find the standard definition for the VR in the literature. However, there appears to be some common understanding about what VR is all about, the different is found only in semantics from author to author. The term VR was coined by Jaron Lanier the founder of VPL Research in the US,[2] one of the original business house selling virtual reality systems. The term was defined as "a computer generated, interactive, three-dimensional environment in which a person is immersed (Aukstakalnis and Blatner 1992)".

Simplistically, VR is an artificial environment created using information technology tools (both hardware and software) and presented to the user in such a way that it appears and feels like any real environment. It is important to note that the virtual world is interactive which makes the user completely immerse him/herself in an artificial world away from the real surroundings. To experience virtual reality, the individual needs to use two of its five senses: sight and sound. To experience/sense mostly the three dimensional images devices such as frequency modulators, mouse, joysticks, earphones, special gloves, head mounted display, and goggles are used. All these devices work on inputs from a computer system.[3]

**Fig. 1** Holding a ball with two virtual hands; the opaque hands show the positions of the virtual hands, the wireframe hands show the positions of the user's real hands. They are, in contrast to the virtual hands, able to penetrate the ball. (Source: Please refer footnote No 4)

It is important to note that mostly it is not been possible to generate an exact copy of the real world. There would always be some form of a difference between real and virtual world. Therefore, the fundamental differences exist between the real and the virtual world. A job which is actually simple turns out to be very difficult in a VR environment both from the point of view of designing and execution.

A simple act of holding a ball in two hands is much complicated in virtual world. In reality, a ball is kept hold off with two hands, the position of the hands is determined by the surface of the ball and control of the ball is provided by the haptic (haptics = touch = connection) and the visual senses of the human. In a virtual environment, where no haptic feedback is provided, the control of the ball must exclusively be accomplished by the visual system. There are several aspects which make it much more difficult to control the ball in the virtual environment than in reality. Hence, the user needs to be trained to work in a atmosphere in which he/she is not really holding a ball (in fact he/she is not holding anything), he/she has to position his/her real hands according to the visual movement of the reproduction of his hands. This causes a completely different stimulation of user's muscles than with a real ball (no weight and no counterforces from the ball). Also, the positional quality of the reproduction of both the ball and the hands in most cases is not perfect[4] (Fig. 1).

The entertainment industry which uses the techniques of VR routinely is trying to improvise the existing concept of VR. The idea of 4D and VR has its importance more for the entertainment industry. The term "4D" denotes the fourth

[1] The Sensorama was a machine that is one of the earliest known examples of immersive, multi-sensory/multimodal technology. Morton Heilig, in the 1950s saw theater as an activity that could encompass all the senses in an effective manner, thus drawing the viewer into the onscreen activity. He dubbed it "Experience Theater", and detailed his vision of multi-sensory theater in his 1955 paper entitled "The Cinema of the Future". In 1962, he built a prototype of his vision, dubbed the Sensorama, along with five short films to be displayed in it. Predating digital computing, the Sensorama was a mechanical device, which still functions today. The Sensorama was able to display stereoscopic three-dimensional images in a wide-angle view, provide body tilting, supply stereo sound, and also had tracks for wind and aromas to be triggered during the film. Unfortunately, Heilig was unable to obtain financial backing for his visions and patents, and the Sensorama work was halted and today remains primarily a curiosity in the expansive lore of VR. The details are available at Rheingold (1992).

[2] The term VR was popularized by him in early 1980s. He started a project on "post-symbolic" visual programming language and subsequently stared his company VPL Research which incidentally filed for bankruptcy in 1990. The acquisition of VPL Research's patent portfolio was done by Sun Microsystems' in February 1998.

[3] http://searchcio-midmarket.techtarget.com/sDefinition/0,,sid183_gci213303,00.html and http://www.webopedia.com/TERM/M/MO.html. Accessed 12 Sep 2010.

[4] Leonhard Vogelmeier, Harald Neujahr and Dr. Peter Sandl, "Interaction methods for virtual reality applications", available at http://ftp.rta.nato.int/public//PubFullText/RTO/MP/RTO-MP-HFM-136///MP-HFM-136-14.pdf. Accessed 12 Nov 2010

dimension.[5] This concept need not necessarily involve any major role for computer software but includes more of physical effects. Here the spectators wear 3D glasses and as per the demand of the particular scene theaters are designed to shake, spray water, introduce smells and even spray air at audience to generate different effects.

There are few other ideas in practice which fabricates the reality. Augmented reality (AR) is one such idea which is about live direct or indirect view of a physical real-world environment. Here the elements of reality augmented by virtual computer generated sensory input such as sound or graphics. If virtual reality is a complete immersion in a digital world, AR is more a digital overlay onto the real world. It augments the real world with digital data making it more exciting than a completely fictitious environment. An AR example could be witnessing the world around us as seen through our phone's camera juxtaposed with other inputs like place information based on GPS (Schonfeld 2011). Another much discussed concept in this domain is that of Mediated Reality. Here the view of reality is modified by a computer intern enhancing one's current perception of reality.[6] Another similar notion is a mixed reality (MR). It is a kind of VR but a broader concept than AR, which augments the real world with synthetic electronic data. On the opposite side, there is a term, augmented virtuality (AV), which enhances the virtual environment (VE) with data from the real world. MR covers a continuum from AR to AV Tamura et al. (2001).

Presently, the literature and various ongoing debates on the subject of VR, the views of the scientists working in this field and the general perceptions demonstrate that VR encompass large and at times diverse field of ideas and technologies including both teleoperator and virtual environment systems.[7] At places, people use the terminologies such as virtual reality, virtual environment, telerobotics, augmented reality, and synthetic environments synonymously. It is important to note that since this field of research is still emerging and has an element of multidisciplinary approach on occasion, every new idea instead of becoming a subset of the VR field is getting projected as a new field of development. May be at a theoretical level, such distribution is essential for better understanding but at times at the practical level it becomes tricky to discuss the technological progression as a separate entity particularly when there is an overlap of ideas with regards to various categories.

VR is one technology which is expected to have a wider military applicability and a universal security appeal. This technology has the potential to influence the future of global industry in general and military industry in particular. Presently, the research and development in the VR arena is at varying levels of attainment in different parts of the world. The accomplishments of this technology are yet to be proven but many analysts envisage that this technology could bring in revolution with significant breakthroughs in the near future.

Figure 2 shows a simplistic depiction of the concept of VR.

## 3 Military efficacy of VR

It is a known fact that technology is extremely important for military effectiveness for any nation-state. Induction of new and emerging technologies promises a qualitatively superior military force capable of addressing both conventional as well as asymmetric threats. The military concepts like the revolution in military affairs (RMA) are dynamic in nature and deal with introduction of technological and doctrinal changes in the armed forces. Recent revolution in the information and communication technology (ITC) sector has brought in induction of various new RMA technologies in the militaries. Modern day armies are found inducting offshoots of various advancements in technologies such as nanotechnology, biotechnology, robotics, cognitive sciences, and few others into their scheme. Military technologies are also found using various computer simulations of systems enabling them to perform operations on the simulated system and demonstrating the effects in real time.

### 3.1 Simulator technology

Training is one area where VR technologies are finding wider applicability in the militaries. The reasons that have driven the military to explore and employ VR techniques in their training are basically to reduce exposure to hazards and to increase stealth (Herrero and de Antonio 2005). Simulation of reality is essential for the militaries for a simple reason that there cannot be 'on job training' as far as warfare is concerned. At times, it also becomes extremely difficult to demonstrate to the military personal the real-life mental and physical challenges of military life. Under such circumstances, the need arises to fugue the reality in some form or other. This is where the VR applications specially designed for the military could play a major role.

[5] http://www.ehow.com/about_4798680_difference-between-d-virtual-reality.html. Accessed 10 Jan 2011.

[6] http://en.wikipedia.org/wiki/Mediated_reality. Accessed 21 Nov 2010.

[7] For all such systems, the basic components are a human operator, a machine, and a human–machine interface linking the human operator to the machine. In case of a teleoperator system, the machine is an electromechanical tool containing sensors and actuators (telerobot) that efficiently expand the operator's sensorimotor system and thereby allow him/her to sense and manipulate the real environment in new ways. In a virtual environment system, the machine is an appropriately programmed computer. Please refer Durlach and Mavor (1995)

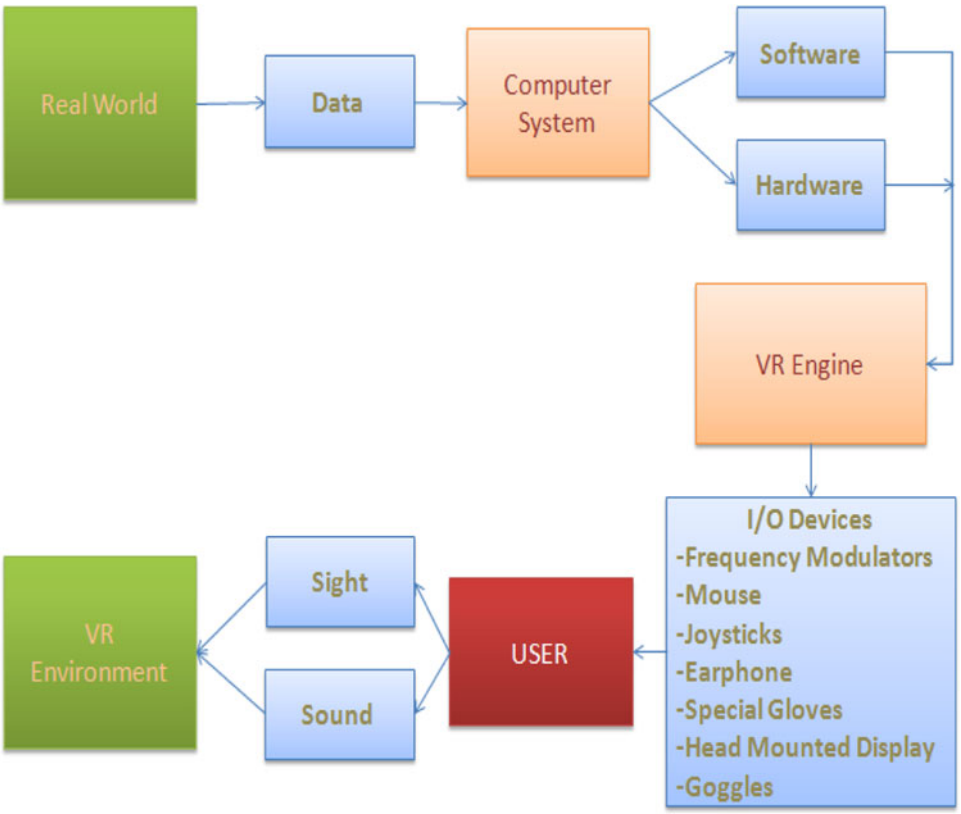


**Fig. 2** Concept of VR

One important aspect of VR-based simulation is that it offers a space to undertake various risky and tricky maneuvers which are difficult to perform in real life on the real equipment. VR makes it possible to simulate an equipment malfunction or bad weather or any unexpected scenario (Molloy 2009). All this becomes possible without causing any damage either to humans or to instruments. VR helps to train pilots to handle emergencies.

North Atlantic Treaty Organization (NATO) in the year 2003 came out with an important report titled "Virtual Reality: State of Military Research and Applications in Member Countries". It has been identified that the "key to the effectiveness of virtual reality for military purpose is the man–machine interface or human–computer interaction. Military personnel must be able to perform their tasks and missions using VR sensory display devices and response devices. These devices must display an environment that provides the appropriate cues and responses needed to learn and perform military tasks. Human factors issues include: determining the perceptual capabilities and limitations of sensory display devices; designing terrain data bases and other displays to meet task performance needs; understanding the human and task performance compromises required by current technologies; evaluating transfer of training and knowledge from the virtual to the real world; and considering the causes and solutions to simulator sickness that can occur in virtual reality". The report identifies basic military applications involving VR as the systems capable of helping to model the weapon systems and to evaluate and test such systems. Also, it has been highlighted that the VR is useful in developing training and learning applications and can play a role to help in mission planning and rehearsal.[8]

Simulators used for flight training could be viewed as one of the early employment of the VR technology. During late 1920's and 1930's, the Link Company (Binghamton, New York) had built flight trainers and many pilots were trained there before and during World War II. Basically, these simulators were used for giving training on the night flying skills. With the maturing of television and video camera technologies, the simulator designers were able to produce a view of the outside world during 1950s.[9] Since, then various useful technological developments are enhancing the simulator technology further and further. The advent of electromechanical analog computer brought in some changes in the simulator designing. However, during the 1950's and early 1960's, the requirements with regard to the motion and visual systems were not resolved

[8] A NATO report titled "Virtual Reality: State of Military Research and Applications in Member Countries", RTO TECHNICAL REPORT 18, St. Joseph Print Group Inc. St. Joseph Print Group Inc. Ottawa, Ontario, Canada, 2003.

[9] http://www.hitl.washington.edu/scivw/EVE/II.G.Military.html.

totally with the available technology. The arrival of digital computing brightened the chances of real-time digital simulation during 1960s. It also improved the flexibility, repeatability of the system and helped to bring in standardization.[10]

For any simulator, the basic requirement is that every instrument must function identically to their real-world matching components/parts. During the last few decades, the major revolution taking place in the informational technology and communicational sciences allows the modern day VR-assisted systems to interface the user to a computer and to undertake various 3D visual tasks and carryout real-time interaction. The usefulness of any VR system comes from the quality of its main feature—the immersion. It is this ability of the VR system which allows the user to become a part of the simulated world which is extremely essential to bridge the gap between virtual and real.

### 3.2 Imperative element of air power

The role of VR in the military domain grows beyond simple flight simulator. Here many times, more than one trainee operates in the virtual world demanding more sophisticated environment often called as advanced synthetic environments (ADS) (Wong 2010). It becomes essential to create air warfare simulation with high levels of realism. For this purpose, it becomes necessary to integrate computer models, simulated scenarios, and various behavioral models, flying platform and weapon system simulators, and other essential war fighting systems. Such synthetic environment could constitute of standalone systems or a network of networks.

Presently, the US Air Force is found investing into such distributed mission training (DMT) capabilities (Lok 2001). Overall, the use of VR offers an alternative to advance tactical flying training as well as helps to develop doctrines and tactics. This also allows the evaluation of operational plans. In years to come, the simulated training is likely to assume more importance for a simple reason that it is cost effective and avoids the loss to human lives. VR technology is expected to reduce the actual flying efforts at least to a certain extent because it offers most cost-effective method for training pilots. Also, lessening in the actual flying activities would play some role toward managing the damages to the environment.

Apart from the US Air Force, various other air forces are using such techniques. They have developed concepts that use virtual air environment (VAE). The Royal Australian Air Force (RAAF) along with their Defence Science and Technology (DSTO) has developed the Advanced Distributed Simulation concept. The various concepts developed involving VR and associated simulation techniques have been put in use for the operational training by the RAAF particularly by their Surveillance and Control Groups (Jon Blacklock and Zalcman 2003). Simulator centres have also been created by the French and German Air Forces. Also, the four nations Eurofighter project have established the Eurofighter Aircrew Synthetic Training Aids (ASTA).[11] This system is rated as one of the best systems in Europe providing leading edge, high fidelity and 360° field of view training. During April 2009, the first ASTA simulator for the Eurofighter Typhoon was made operational for the Italian Air Force.[12] For other air forces such as the Israeli Air Force and in states like Netherlands, the systems are in place for such training activities (Lok 2001). The simulator training has not remained restricted to the training in transport and fighter aircrafts but also covers areas like the unmanned flying machines, e.g., a new Israeli air force squadron dedicated to delivering simulation-based training to helicopter pilots and unmanned air vehicle operators was made operational during the year 2010.[13]

Defence industry is using the VR technology even for the purposes of manufacturing. Sikorsky Aircraft Corp. a subsidiary of United Technologies Corp. during January 2011 unveiled a state-of-the-art virtual reality center for the CH-53K heavy lift helicopter programme. This innovative tool helps identify gaps in a three-dimensional digital environment prior to experimental assembly. This allows cost savings and greater efficiency and helps minimize delays in final assembly of the aircraft. The purpose is to enhance the designer's ability to design an aircraft that is easier to maintain.[14] Mostly, amongst the developing nations most of which do not have their own aircraft industry the simulator training is given by the original equipment manufacturers (OEM).

States like China have developed their own simulator infrastructure. In China, the research and development work related to VR began in the early 1990s. Presently, various universities and scientific establishment are found involved in the development of this technology. In defence area, the work is undertaken at the National University of

[10] http://homepage.ntlworld.com/bleep/SimHist8.html. Accessed 28 Jul 2010.

[11] For more details please visit http://www.eurofighter.com/media/news0/news-detail/article/aircrew-synthetic-training-aids-asta.html and http://www.eurofighter.com/media/news0/news-detail/article/training-days.html. Accessed 23 Dec 2010.

[12] http://www.eurofighter.com/media/news0/news-detail/article/the-first-asta-simulator-for-the-eurofighter-typhoon-operational.html. Accessed 04 Oct 2010.

[13] http://www.flightglobal.com/articles/2010/10/04/348060/israel-opens-helicopter-uav-simulator-unit.html. Accessed 20 Oct 2010.

[14] http://www.defencetalk.com/sikorsky-virtual-reality-for-ch-53k-helicopter-31398/#ixzz1ECGOf1TH. Accessed 12 Jan 2011.

Defence Technology. Here military technologists are working on projects including distributed virtual reality, behavior modeling, image-based modeling and rendering (IBMR) tools, simulation of dynamic ocean waves, and collision detection (Pan et al. 2000). As per the experts, Chinese army (PLA) services use a range of simulators for a variety of training objectives. They make their own individual or crew simulators for ballistic and cruise missiles, 4th gen fighters, trainers, submarines, ships, main battle tanks, other armored vehicles, trucks, long range and shoulder launched Surface to Air Missiles (SAM), shooting and individual soldier combat decision training. However, not much is known about the density of simulator distribution. It is expected that the PLA will be networking various simulators to enable command level and individual combat level mission simulation, even could be joint force simulation on the eve of actual missions.[15]

Particularly, for teaching intricate tasks such as flying it is very important to develop the sense of presence in the training aids to make the learning experience engaging and relevant. It is important for the trainees to experience thoughts, emotions and behaviors similar to those they could experience in a real-life situation. The sense of presence in the training situation also helps in analysing the problems post-training.[16] To enhance the training for controllers and fire observers for the purpose of coordinating airstrikes for close air support combat operations, VR techniques have significant utility. Also, the VR-based simulator systems offer a video with the photo-realistic imagery of the actual range area overlaid on terrain elevation data with three-dimensional enhancements of buildings and vegetation. The virtual pilot gets the ability to identify troops and vehicles on the ground using onboard sensors.[17]

### 3.3 Maritime applications

Apart from aviation, VR is also used for making simulators for ground vehicles and vehicles operating in water. Such simulators come under various categories from single vehicle to a system facilitating complex training missions involving multiple participants acting in various roles. Specific devices are available for army which train soldiers to drive specialized vehicles like tanks or the heavily armored vehicle. It is also possible to conduct training by replicating treacherous weather conditions or difficult terrain including urban combat environment. Also, networked simulators have been designed to allow users to participate in complex war games. The technical requirements for the simulators for the Navy are slightly different. For submarine simulators, there is no need to have windows to the outside world and hence the realistic requirement of 'environment' and 'terrain' does not have much of significance. What is important is to provide realistic instrument readings as the crew navigates through the simulation. However, it is also important to create a sense of immersion as far as possible by physically simulating a diving or surfacing maneuver (Strickland 2011).

Search and rescue (SAR) is an important element of any ship disaster management system. Specialized training is must for the personal before getting employed in the SAR department. VR has got utility with regard to training for such purposes. Such systems are synthesized simulation systems and they integrate various simulators together such as: ship handling simulator, engine room simulator, etc. The system creates a virtual environment with strong immersion effect and provides a realistic simulation system with better environmental realism, physical realism, and behavioral realism (Yin et al. 2010).

### 3.4 Engineering designing

Apart from simulator training, the VR and its allied branches have utility in various other areas directly or indirectly associated with the armed forces. Engineering designing is one such area. The applicability of VR could be wide ranging from the defence industry to local level workshops in various military establishments. VR could assist the process of development of prototypes for various equipments. VR/AR has wider applicability with regard to the manufacturing, maintenance and repair of various military equipments. For addressing issues related to new or unfamiliar piece of equipment instead of opening several repair manuals simply an augmented reality display could come handy. VR systems have proved their utility for consumer designs.[18]

The military's growing interest in virtual reality technology is mainly from cost and safety perspective. It is cost-effective to test conceptual designs with regard to weapon systems or maintenance platforms using VR technology.[19] The technology allows testing the design without building a physical prototype. This saves time with

[15] In conversation with Richard D Fisher Jr. a US based expert on China and author of book China's Military Modernization (Praeger Security International, London, 2008).

[16] For more on this please refer Ch11by Fabrizia Mantovani and Gianluca Castelnuovo, "Sense of Presence in Virtual Training: Enhancing Skills Acquisition and Transfer of Knowledge through Learning Experience in Virtual Environments" in Riva et al. (2003).

[17] http://www.usafe.af.mil/news/story_print.asp?id=123168023. Accessed 12 Jan 2011.

[18] http://www.se.rit.edu/~jrv/research/ar/introduction.html. Accessed 10 Feb 2011.

[19] http://www.designnews.com/article/7775-Military_Broadens_Use_of_Virtual_Reality.php.

regard to development of technology. Battlefield visualization is one more area where VR helps improving army systems. Battlefield visualization is not only a key element in the training regimen but is also vital for determining combat strategies in real time. For VR systems, now it is possible for the military officials to explore a three-dimensional model of an area by viewing it from any angle while formulating strategies and looking for potential logistical problems (Strickland 2010).

### 3.5 Medical applicability

VR has a major applicability in the field of medicine too, particularly in the arenas of image guided surgery. VR techniques are becoming more attractive in the modern day medical science. Techniques like the computerized tomography and magnetic resonance imaging (CT/MRI) scans could be viewed as most commonly used VR techniques in medicine. A MRI scan creates the images of a body structure based on a technique using magnetic field. This technique is extremely useful for the purposes of disease dictation. A computerized axial tomography commonly known as CT/CAT scan uses multiple X-ray images to create a cross-sectional/three-dimensional view of the portion of the body and helps in disease diction.

For many years, the technique of X-rays has been the major component of medical imaging. The advent of the computer has brought in a revolution in the field of medical imaging. During the last couple of years, imaging techniques have grown significantly in their sophistication and can now provide the doctors with high quality three-dimensional images depicting not only the normal anatomy and pathology, but also the vascularity and function. One key factor in the advances in image-guided surgery (IGS) is the ability not only to register images derived from the various imaging modalities amongst themselves, but also to register them to the patient. The other crucial aspect of IGS is the ability to track instruments in real time during the procedure, and to portray them as part of a realistic model of the operative volume. Stereoscopic and virtual-reality techniques can usefully enhance the visualization process (Peters 2000). Such techniques have major utility in spinal and orthopedic applications too. From the armed forces point of view where the energy is mostly critical and different form ordinary accidents (battlefield injuries and damages close to the human body are different than the normal cases), such techniques are very useful.

Haptic technology is increasingly finding utility in the field of medication. This technology using interfaces with computers to produce the sense of touch by applying different forces. "These forces can make virtual images/reality seem real to the touch. The interfaces allow somebody to touch, feel, stimulate, and alter dimensional-objects in the virtual realm. Telerobotics is a big area using haptic systems. Telesurgery is when a surgeon is not present in the room, and can do the surgery from the virtual realm (Boduch 2010)." The uses of VR techniques for medicine have major utility for hospitals both in the civilian and military domain. Particularly, the techniques like the telesurgery could be handy in case of forward bases for the armed forces where minimal medical facilities are available.

VR technology also has utility for a variety of psychosocial interventions. In recent years, a growing number of occupational therapists have integrated video game technologies, into rehabilitation programs. They have been used successful in increasing patients' motivation and encouraging full body movement. To make systems which are more patient friendly few low-cost, VR-based system have been designed which use auditory, visual, and haptic elements to provide extrinsic feedback and motivation to patients (Anderson et al. 2011). Armed forces medical community has to address many patients with physical rehabilitation and the uses of VR-based techniques help them not only to assist patients but also to improve the moral of troops.

Militaries are found using the VR technology beyond the routine medical practices. They are found using the virtual world to treat traumatized veterans of the Iraq war. The aim of the study is to give the troops a high-tech way to confront and overcome mental war wounds. Here with the help of VR technology electronically, a virtual Iraq is created with added effects of sound, light and other effects. In this type of exposure therapy, a therapist helps the soldier to confront the memories, so that he or she becomes less afraid of those memories, thus being able to look at the situation differently and more rationally. Here a variety of scents are manufactured, both pleasant and unpleasant. The smell of fire, diesel, cordite, body odor and burning rubber also plays a role to facilitate memory recall and emotional processing. The biggest advantage of such therapy is that it allows the replication of the war zone in a safe way that therapists can control.[20]

### 3.6 Virtual reality in warfare

Military technologists are of the opinion that the technologies like VR have the potential to redefine the modern day warfare and there is a need to research more on such technologies beyond the fighter pilot heads-up-display and medical applications. Currently, the work is under progress to develop the soldier helmets which could communicate with a main server that collects and delivers three-

[20] http://www.stripes.com/news/military-uses-virtual-therapy-to-help-troops-heal-wounds-1.92986.

dimensional information onto the wearer's goggles in real time. With the help of a color code, the soldiers would be warned of the things such as friendly forces, potential danger spots, impending air-raid locations, rendezvous points and many other important aspects. Also, the US military industry is working toward the development of a system of lightweight sensors and displays that collects and provides data from and to each individual soldier in the field. This includes a computer, a 360° camera, UV and infrared sensors, stereoscopic cameras, and organic light-emitting diode (OLED) technology translucent display goggles (Cameron 2010). Robotic technology is one interdisciplinary technology which could be associated with the VR in a significant way and could fine its utility in training, avionics, intelligence gathering, bio-medicine and various engineering applications.

Defence industry in the US is working on few projects based on the requirements put forth by the military. The US government is supporting such ventures. For helicopter crewmen to undertake specific tasks, it becomes essential download computer data and graphics from thermal cameras. However, mostly it is not possible to accommodate traditional monitors due to lack of sufficient space. The answer to this is the use of a head-mounted display (HMD) which could combine a small, over-the-eye monitor mounted to an adjustable band worn around the head or helmet. Obviously, such equipments are expected to withstand rugged conditions, including extreme climates, precipitation, and dust. Such HMD departs from a traditional monitor in that it offers augmented reality, meaning the transmitted data displays transparently so that the user can see through the image. Here the image is laid over the view of the real world. Augmented-reality HMD technology can play an important role on today's digital battlefield. It offers a solution to the problem of non-see-through displays which inhibit a soldier's view (Howard 2007).

VR-based soldier training allows to train the troops by creating foreign zones in own land.[21] The virtual training device creates a realistic simulation of overseas territory to prepare soldiers for future international deployments. Such systems as multiple utilities, it allows creating a battlefield scenario with the adversary and also helps to train the troops to operate in a likely UN mission scenario or any other joint deployment with the troops of the other states.

From a market perspective, the military simulation and virtual training market are growing rapidly. It's sector is fast emerging as an important sector in the defence industry. It is expected that as states would start reducing defence spending in the face of economic pressures or would attempt to reorganize the training, technology and hardware priorities the military simulation and virtual training would grow as a cost-effective alternative. Presently, the US dominates the military simulation and virtual training market. But, the demand is growing globally from the UK and France in Europe and states like Saudi Arabia in the Middle East. China and India are identified as the two crucial future emerging markets with a very strong growth in spending.[22]

The likely maturing of this technology in the military domain in coming years also brings to the fore in the need to address the policy issues (Wilson 2008) which are evident today and could surface in the future. For this purpose, it is important to appreciate the fact that VR and its connected branches of technology are likely to find their utility in the military domain well beyond training purposes. Presently, there is no palpable global strategy to judge the military utility and performance of existing and emerging VR technologies. Like all other developed military technologies, it is essential to establish basic understanding at the global level with respect to VR. This is because when such technologies would be used for operational purposes a need would arise to formulate specific guidelines and also certain doctrinal changes could be envisaged both at policy and operational levels depending on the status of technology at that point in time. In near future, various issues could come to the fore with regard to standardization of this technology, what could be the just and unjust aspects of this technology depending on the established global norms, nature of technological infrastructures (communication/satellite/ground based) required to administer this technology etc. Also, there could be issues with regard to international transfer and sale of this technology. The dual use aspects of this technology and related global concerns could also emerge in the near future.

## 4 Recent and future research

The growth of VR for the militaries needs to be viewed slightly differently in comparison with some other technologies. This is because VR is per say not a platform technology like the combat aircraft, ship or a tank. It is more of an application oriented technology. At the same time, its induction needs to be viewed bit differently in comparison with other application-oriented technologies like the information technology (IT). This is because in

[21] Army Uses Virtual Reality Soldier Training, 01 Nov 2010, http://www.armedforces-int.com/news/army-uses-virtual-reality-soldier-training.html.

[22] As per the Defence Market Research Reports titled "The Military Simulation and Virtual Training Market 2010–2020". This report has been published by Companiesandmarkets.com is a leading online business information aggregator. Information is available at http://www.reportlinker.com/p096388/The-Military-Simulation-and-Virtual-Training-Market-Analysis.html#ixzz1G09RZYAV.

case of IT, one of the major applicability is to increase the efficiency of the existing systems but induction of VR at places demands the structural and doctrinal changes. Also, some VR and cognitive science-based applications raise moral issues and more importantly VR still remains in the realm of developing technology, particularly in the military context. Because of these reasons and other factors like the cost and the technological knowhow, only few militaries at present at making concentrated efforts to induct this technology. On the other hand, not much of information is available in the open source literature about the military applicability of this technology probably because of the inherent nature of military secrecy.

The research in military VR appears to be mainly undertaken by the US and few European countries. The government organizations like the US Naval Research Laboratory (NRL) and few other military research institutes are involved in conducting military VR research. The Swedish military is doing some innovative research in VR. The work is being carried out by three military administrations, FOI—Swedish Defence Research Agency, FMV—Swedish Defence Materiel Administration, and SNDC—Swedish National Defence College. For Military Operations in Urban Terrain (MOUT), they have developed a map which offers three-dimensional information with some operational functionality which gives cognitive decision support for the operator. Such maps have utility as an information and decision aid during an exercise or as a planning- and evaluation-tool. They are also working on future soldiers, computer generated forces, human behavior modeling, and flight simulator technologies (Borgvall and Lif 2011).

As mentioned in the paper earlier, one of the significant VR trends for the future appears to be the adaptation of video games for military purposes. Particularly, the modern day gaming industry is keeping in view the increasing speed of home computers for designing the games (Haar 2011). They are also found developing more realistic gaming modules to cater for increasing market competition. Because of this slowly the difference between games and military simulators is found declining. It is expected that in near future militaries would develop some of their VR-based tools by modifying the available games to match their requirements instead of reinventing the wheel.

Currently, research is being undertaken in the field of Virtual Reality Geographic Information System (VRGIS). This new generation of GIS combines three-dimensional GIS, visual technology, and virtual reality technology. This system could be of major use for the data management, analysis, and graphical display of three-dimensional space (The Research of Virtual Reality Geographic Information System 2011). Militaries could use this system by replacing their existing two-dimensional GIS space data models. Also, once fully developed, militaries could juxtapose the VRGIS technology on their various other hardware and software tools as the requirements.

Any further research in the VR field related to medical applications would have utility for the militaries. Certain specific research needs to be undertaken in this arena to cater for military requirements. Handling anxiety is important particularly for the soldiers wounded in wars or while handling other security-related tasks. There is a need to develop the cognitive and behavioral therapies keeping military needs in mind. Also, particularly for the parachutist jumping training simulators are being used for many years. They have helped in minimized injuries significantly. In the twenty-first century, the roles of militaries are constantly getting redefined and are engaged to handle natural disasters like earthquakes, tsunamis, nuclear disasters to antipiracy operations. Under such circumstances, it is essential to train the troops adequately and VR could offer innovative solutions in this regard.

## 5 Conclusion

Over the years, modern militaries are increasingly found using VR technology successfully. Significant developments in the information and communication technology field have brought in rapid resolution in VR technology. For all these years, training has one area where VR has found maximum utility and the same would continue in the near future too. However, it is well understood that the virtual training may not be able to replace the physical training or actual operational training and experiences gathered during various military exercises but still it could play a major role in various other aspects of training both because of technological and financial advantages.

The importance of VR is likely to increase in near future much more for a variety of reasons. First, rapid developments in technology are offering new near real solutions and making wealth of tools available to cater for various military requirements beyond training. Second, twenty-first century military challenges are both conventional and asymmetric in nature demanding evolution of innovative technologies to address them and VR could offer some of the answers. Third, VR offers solutions without causing any loss or damage to humans and equipment. Fourth, technology is now available at a manageable price. The present generation personal computers have the capabilities of the supercomputers of yesteryears. Various sophisticated accessories required for the VR experience are available at the affordable prices. Fifth, the VR technologies successfully keep the ‘clutter’ away while taking operational decisions because it works on different dimensions simultaneously and make available only the required

information. This allows the decision maker to take a correct, timely and quick decision. Because of all such advantages, more states are likely to invest in VR technologies for their militaries in near future. Various developments in the VR technology are also been aptly supported by the global video gaming industry. The future advancements in the video gaming industry are likely help the military VR developments too. Overall, the VR technologies demonstrate the potential to the change the nature of warfare foundations for the future.

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