Possibilities of using virtual reality technology in skills development

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Abstract

With changing threats and rapid technological progress, society is facing significant changes and challenges. Ensuring that people have the skills and capabilities to meet these challenges is key. One 'tool' for this could be the use of virtual reality (VR). The VR research community is becoming increasingly active in the search for solutions. In this article, we have tried to summarize the concepts related to VR education and training, followed by the challenges of using VR technology and the solutions already implemented through examples from the US, France and China. We then concluded the article by outlining possible future concepts that will need to be developed to implement VR training, with a particular focus on the issues of military training.

Keywords:

Virtual Reality (VR) has emerged as a new field of multidisciplinary research. In the last ' few years, its scope has expanded beyond academic research and industry is investing heavily in this field, both for research and for the development of various VR-based products. Various industrial sectors such as information technology, biomedical engineering, structural design and the technology sector for training aids are investing in this technology. The military industry, always looking for new ideas, is slowly becoming one of the main investors in VR. Like many other scientific discoveries, VR is rooted in science fiction novels and essays and is therefore a centuries-old concept, but in the past, the concept was defined differently. Many generations ago, the Greek philosopher Plato (427-347 BC) offered the rulers of the day a perspective on political decision-making, and in doing so, he promoted a concept similar to that of virtual reality in his day. He urged them to make political decisions strictly based on certain knowledge and insights, not on intuition. Over the years, the concept of virtual reality has evolved considerably. In particular, important developments in the information technology sector have revolutionized the definition of virtual reality considerably.

1. VR and related concepts

Before starting to analyze the topic indicated in the abstract, i.e. the possibilities for military use, let us first consider what the terms used mean. The topic under consideration is relatively new and therefore lacks a universal definition, the phenomenon has been approached in many different ways and, of course, each has had a different view of what is important. Linda Jacobson[1] and Steve Tice[2] defined the term as follows: 'In our view, "virtual reality" refers to technologies or environments that provide realistic cues to some or all of the senses sufficient to induce a willing suspension of disbelief in the participant. A successful VR application provides quality content and experience; thus, virtual reality essentially represents an evolution in user interface studies and human factors-based application design." (Tice and Jacobson 1991)

To clarify the concepts, let us look at the difference between Augmented Reality (AR) and Virtual Reality (VR), because these two concepts are sometimes erroneously referred to together, mainly because of the similarities between the two technologies. AR, as the name suggests, adds (extends) information to the actual reality. But the essence of VR is that it takes the user out of reality and places him or her in an artificial space. The aim of VR is therefore to make the virtual space as plausible as possible by using visual elements, sound effects and a variety of accessories. However, life is more complex than that, as there is also the concept of Mixed Reality (MR). MR combines elements of AR and VR by adding digital objects to the real space and allowing these now virtual elements to interact with reality. To conclude the clarification of the concepts, we should also

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mention Augmented Reality (XR), where 'X' refers to the variables that the above technologies will include in the future.

The picture can be further nuanced by looking at the fact that the aforementioned Linda Jacobson, in her book "Cyberarts: Exploring Art & Technology" (Jacobson 1995), distinguishes between four different virtual realities:

- Perpetual virtual reality;
- Desktop virtual reality;
- Projected virtual reality;
- Desktop Virtual Reality; Desktop Virtual Reality; Simulation Virtual Reality.

However, there are other types of virtual reality, so let us look at an extended list:

- Perpetual, first-person singular virtual reality (e.g. head-mounted displays (helmets), fibre-optic cable gloves, position tracking devices and surround sound systems).
- Augmented reality, which creates a transparent layer of computer graphics that highlights elements of reality and aids understanding.
- Virtual reality is viewed through a window, where you can view the virtual three-dimensional world through a monitor and navigate using tools such as a mouse.
- The mirrored world allows a second-person experience, where the viewer is outside the imaginary world but can communicate with persons or objects in the projected world.
- Waldo World (virtual persons) is a blend of digital puppetry and real-time computer animation.
- A relatively small-scale projected virtual reality theatre controlled by a number of computers.
- A car simulator environment is essentially an evolution of a traditional simulator.
- Cyberspace is an artificial reality on a global scale that can be viewed by multiple people at the same time via a computer network.
- Remote Presence/Teleoperation appears as if you are in a place that is different from your real location.
- A viewing dome is an immersive, multi-user, single-projection virtual reality environment, where the user enters a "viewing dome" and finds themselves in a hemispherical space that provides complete immersiveness.
- The Experiential Learning System, which aims to provide the military with a high-fidelity system based on virtual reality and artificial intelligence to ensure realistic military exercises.

The definition of the term is therefore quite broad. In the first part of this article, we will look at the areas where VR can be used to help with workforce training. Traditionally, training took place in classrooms or laboratories through presentations and practical exercises. However, it has now been shown that VR can drastically reduce the cost of training while improving the effectiveness of training. (This is why we will compare the two forms of training, focusing on military training.)

2. Traditional training or VR

Since all comparisons are subject to errors of subjective judgement, we will keep the comparison of the two types of training at a general level and use only listed facts to support our arguments, rather than a deeper analysis. Let us first look at some of the possible disadvantages of traditional education:

- Getting to the training sites can be time-consuming and involve extra costs.
- It can be more expensive to produce training materials.
- Allowances for trainers may be an extra cost.
- Less effective training due to less attractive and unintuitive visuals in classrooms (e.g. lack of 3D animations)
- Some skills cannot be taught in a real-world classroom environment (e.g. emergency procedures)

Of course, VR training does not automatically guarantee lower costs, but the benefits that these systems bring to trainees can justify the investment. VR also reduces training costs by increasing the number of training scenarios. This is possible because VR training scenarios are mainly computer-generated 3D graphics, VR developers can easily create different scenarios from existing 3D assets that can be used repeatedly to train different people. A particular advantage is that the scenarios available online are convenient and inexpensive. At the same time, VR technology also allows students to learn in their own homes, which further reduces additional costs (electricity, water, heating, etc.). Another feature of VR training is that it allows students who otherwise have difficulty coping with teacher supervision and the presence of observers to do well. There are, of course, training situations that need to take place in the presence of the instructors, because it is necessary to warn students of any problems they may be experiencing and to draw their attention to negative trends in their performance. VR also allows training to be carried out safely in situations that could lead to a fundamental hazard (fire, explosion, etc.).

The scope of this publication is limited to VR training. Accordingly, training in other augmented reality domains (e.g. augmented and mixed reality) will not be considered. VR training can be evaluated from a myriad of perspectives: from software selection to software development, from graphical fidelity to runtime efficiency, and from interaction techniques to interaction realism. The VR training creation process can be divided into three stages:

1. task analysis (hierarchical[3], cognitive[4]);
2. preparation of a training scenario[5];
3. implementation.

The main difference between traditional and VR training is the implementation. Traditional training methods are usually based on

[3] HTA (Hierarchical Task Analysis): describing goals that are made up of different units.
[4] CTA (Cognitive Task Anlysis): focuses on dealing with unexpected situations.
[5] The work on the development of efficient and comprehensive representations of training scenarios not only provides a general framework and new ideas for the design of new VR training applications, but also offers a theoretical basis for the development of procedural approaches for the automatic generation of virtual training environments.

technical manuals or multimedia resources, whereas the implementation of VR training is nowadays based on modelling and simulations, which are essential components of VR training software.

2.1. VR training in military training

It is undeniable that military training can be dangerous. Many soldiers die every year from non-combat causes or accidents. Technology is constantly evolving. We can now simulate different environmental conditions, such as day and night, and take into account different types of weather and other scenarios. NATO was quick to recognize the potential of VR technology. Already in February 2003, the NATO Research and Technology Organization (RTO) published a technical report entitled "Virtual Reality: the state of military research and applications in member countries". (RTO/NATO 2003) The military has started to use simulation software and serious games as training tools, so it has started to exploit the potential of virtual reality. The United States, for example, has developed the Flooding Control Trainer (FTC) to train recruits in the US Navy in various skills. US Aviation has begun experimenting with VR training through the Aviator Training Next (ATN) program to supplement traditional hands-on training. Their preliminary results suggested that VR training produced pilots of similar quality and competency as pilots trained in "real" aircraft. One of the main drivers for these improvements was precisely the fact that traditional training methods are often limited by the real training environment and some specialized tools or equipment. VR training provides a safe, controlled virtual environment at a relatively low cost for soldiers to practice their technical skills and develop their cognitive functions.

Another thing that can be said about military training is that many traditional training methods require a specific location or equipment.[6] As examples, let us look at some VR training already in operation. One of the main training tools used to train all Landing Signal Officers (LSOs) for several decades is the 2H111. This simulator is located in Oceana, Virginia, and the device itself is housed in a two-story room and consists of several large screens and physical displays of actual equipment used by LSOs in their operational environment. Young officers serving in this speciality typically encounter this system only during a short formal training period (six one-hour sessions), leaving more dead time in training. While the 2H111 experience is extremely valuable for any LSO officer, the time spent using the training tool is undeniably too short. The need to provide LSOs with an unlimited number of training opportunities that are not constrained by space and time, coupled with recent advances in commercially available immersive technologies, has provided an ideal platform to create an easy training solution that fills these gaps and goes beyond the options currently offered in the 2H111 simulator. The main objective of the 2H111 training capabilities is to ensure that the

[6] These field and portable devices can be a starting point for further developments. (See previous articles by the author.)

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new prototype system is mapped to support the main training objectives of 2H111, the design and development of the prototype training system. The results achieved so far show that it is definitely time to renew the LSO training to take the leap towards immersive VR and provide an ideal platform to create a lightweight training solution that addresses the training gaps and goes beyond the capabilities currently offered in the 2H111 simulator.

Another such training tool, which is also not new, in which VR has greatly improved the quality and condition of training compared to traditional methods and which helps French Army infantrymen master the calibration procedure for infrared sensors is the 21st-century combat system called FELIN[7]. In order to practice on the actual FELIN system, soldiers have to practice several times on the conventional software until they get it wrong.

FELIN is a system developed by the French Army's Infantry Soldier Modernization Programme. The complete system was developed by a consortium led by Sagem as integrator. FELIN combines the modified FAMAS[8] machine rifle with a range of other electronics, clothing, helmets and body armor. The portable electronic platform (PEP) is the core of the system. All the electronic equipment of the system is connected to the PEP. These are the tactical radio, the weapon and helmet mounted and handheld optics, the commander's battle management system (BMS) terminal and the batteries. The PEP includes a wearable computer that uses a USB 2.0 interface for data communication with the communication and navigation unit. The suit contains two wired networks. One transmits electrical power to all systems. The other provides the data connection. The system's communication device is the Thales TRC-9100 voice and data radio. The radio has an integrated GPS receiver. A SitComdé tactical terminal in the commander's kit connects to the SITEL combat management system installed on the combat vehicle. The device with color touch screen allows the driver to manage the tactical situation, with integrated messaging and friend/enemy situation display. The handheld optics is the JIM LR (long range) portable multifunction infrared telescope, a member of the Sagem JIM modular optics family. These devices can also be equipped with optional features and functions to meet requirements. The biggest improvement is that while the conventional system only provides soldiers with a 2D program to practice the calibration procedure, the new VR method allows them to practice in a virtual environment with a 3D-printed rifle model, which provides similar control and feel of use as its real-life counterpart. An ad hoc study was carried out on a group of French soldiers to compare these two methods. The results showed that the VR method greatly improved the soldiers' learning efficiency and their intrinsic motivation to perform training tasks. The US and French training tools using this VR technology illustrate the ambitions of both countries. All of the developments already implemented have already

[7] Fantassin à Équipements et Liaisons Intégrés, Infantry soldier with integrated equipment and links.
[8] FAMAS: Fusil Automatique vagy Fusil d'Assault, MAS – Manufacture d'Armes St. Étienne, Automatic rifle from the St Etienne arms factory.

been incorporated into training exercises in order to reduce the number of accidents during training. With these training tools, it may be possible in the future to minimise the risks during training operations.

2.2. VR and military equipment training

In the next section, we looked at the possibilities related to the training of weapons and other military equipment, in short, military equipment. The training of military equipment has its own notable feature, namely the need to train troops in the equipment to be used in combat before deployment. It is also a specialty that the training concerns the actual equipment of the army, ensuring that VR technologies will also meet specific requirements. In general, however, the educational equipment of military training sites (academies, universities, university faculties, training centres) is not in line with the training equipment of the troops and often lags behind the pace of renewal of the troops' equipment. Therefore, a common problem in current military college and university equipment training is that the equipment is incomplete and outdated, the instructional layout of practical operations training is more prominent in equipment instruction than actual deployment, causing students to lack practical proficiency in the equipment, and the teaching effect of practical operations is generally unsatisfactory. The main reason for this is the lack of effective teaching resources, according to a summary of traditional practical training, the following problems mainly arise. Even if the problem of financial expenditure is not taken into account, due to the strict management of actual combat equipment and the fact that military equipment used in education and training is not usually active military equipment, it is true that the production of a model of military equipment for educational purposes can significantly increase the cost of procurement.

In the field of security and defence, training is considered by all forces to be one of the key factors in developing soldiers' skills in tactical operations. Advances in technology and communications have enabled the development of new technological tools to be efficient and at significantly lower operating costs. This section presents the design of a virtual firing range for one of the key training tasks, simulating an open polygon that includes the recreation of real scenarios, 3D objects, silhouettes, targets and weapons from each region of the country. The soldier performing the individual firing task is modeled as a 3D object, positioned relative to the virtual environment on the firing range. The VR environment could include multiple virtual environments (e.g., jungle, urban, rural, coastal, mountainous, etc.). Preliminary published results in usability showed that participants perceived realism in the scenarios and the 3D objects that comprised them. Evaluations of the tools used showed that virtual reality goggles and VR weapon controllers facilitated the visualization and interaction of virtual scenarios during training. Based on

this, it can be said that the virtual shooting range mentioned as an example can be a useful and complementary tool for training military personnel and developing the skills needed to carry out tactical operations. It could be a cheap technological alternative, reducing risk, and increasing the time and number of training sessions.

After building each feature module of virtual training software, a full debugging of the software should be performed on the Unity 3D platform to find software loopholes and optimize the software locally and globally to underpin the final software release. Software debugging mainly includes the following aspects:

- Does the graphical interface adequately represent the real operational steps?
- Is the animation composition smooth and correct?
- Is the background information included correctly?
- Is the operation of each function smooth and correct?

To summarize, in the case of software running on the Unity 3D platform, the exercises carried out so far have demonstrated that virtual training software can be a good complement to the teaching and training of military equipment and has good prospects for military education and training.

3. What could the future hold?
The metaverse and the army

In this chapter, we look at what the future might hold for us. As VR technology continues to evolve and its use becomes more diverse, we have selected an area where recent research and future prospects may be worth exploring from a military perspective. The first area under consideration is image fusion, which is currently being widely used as an important branch of multi-sensory information fusion. This area may also be worth exploring because the development of existing image processing software is conducive to further analysis of images, but today, many problems still face operators in developing image processing technology.

The NUKE software was "arbitrarily" used for the analysis, mainly because it does not require a specific hardware platform (x86-64 processor, 5.70 GB free disk space, 8 GB RAM, 1280X1024 pixel resolution and 24-bit color, graphics card with 512 MB memory and driver support for OpenGL 2. 0), support for all major operating systems (operating systems already tested: macOS Big Sur 11.x, macOS 12.x Monterey, Windows 10 or 11, CentOS 7.6), while providing users with flexibility, efficiency and full functionality. The latest version of the NUKE 3D system (14.0) has enabled users to work more efficiently with modern 3D scenes by introducing a new USD-based beta system. Nuke also integrates the famous Primatte[9], Uimatte and Keylight encoding plug-ins by

[9] Primatte Studio is the world's best software-based key solution that not only includes Primatte 3D key cutting technology, but also includes a custom on-screen toolbar that guides users through the key cutting process, ensuring a perfect key every time.

default, giving unlimited possibilities for post-coding work. Based on the software's powerful image processing function, it performs experiments and analysis on image fusion algorithm, and in the proposed image fusion algorithm, it provides the experimental basis and images for research of the proposal and application. From these technical specifications alone, it is clear that NUKE, although primarily designed for artists, can be effectively used in education, including military education and training.

After analyzing this example, let us return to the general issues of metaverse and educational innovation and the development of metaverse educational applications and their impact on military training. This section also starts with a definition of the basic concept, namely metaverse. In the simplest terms, a metaverse is the concept of an online, 3D universe that combines several different virtual spaces. It can also be thought of as a future version of the internet. However, the metaverse does not yet exist, but some platforms already include "metaverse-like" elements. In more concrete terms, "The metaverse is a post-reality universe, a persistent and real multi-user environment that combines physical reality with digital virtuality." (Mystakidis 2022)

Whatever the definition of the metaverse, it is now clear that China, which is also at the forefront of artificial intelligence research, is aiming to play a leading role in all the related technology industries that will serve as the backbone of this emerging technology. China's role is also worth examining because most talk of the metaverse is about civilian applications, but there is growing debate in China about its potential military applications. As a starting point, it is argued that although the metaverse is still in its infancy, the downgrading or disabling of the metaverse could have serious consequences as society and even the military become increasingly integrated and reliant on this technology. The importance of its military use has already been published in several scientific analyses, already referred to under the new name of "battlefield technology" and aimed at finding possible methods of attack on the adversary's own metaverse. A study by the prestigious New Media Research Centre at Tsinghua University has already identified security concerns that could be significant for military use. A study by the China Institute of Contemporary International Relations (CCIR) has already identified generalized national security risks. The study identified three areas of concern:

1. Technological hegemony, i.e. that some countries develop metaverse technology faster, can cause instability in capabilities and access.

2. Cyber and data security, as relying on and using the metaverse, will make data sharing more sensitive and is considered a category of critical infrastructure.

3. How metaverse will change a country's politics, economy and society.

February 2022, the People's Liberation Army (PLA) joined the enthusiasm for the metaverse and celebrated Chinese New Year with a Spring Festival on the military network in virtual space. The event was hosted by avatars and broadcast live. The

description of the event boasted, "Participants using HTML 5 were guided by the integration of artificial intelligence, image recognition, semantic analysis, holographic imaging and other technologies." (Qingxiu, Shiyang and Chenxu 2022) The attachment to the metaverse is also reflected in China's "National and Cyberspace Security Strategy", which focuses on the importance of sovereignty, the digital economy, norm formation, and the cultural impact of cyberspace. The authors write, "Cyberspace has become a new field of human activity with the same significance as land, sea, air, and space, national sovereignty has been extended to cyberspace, and cyberspace sovereignty has become an important part of national sovereignty." (China Copyright and Media 2016)

Since the metaverse represents the new frontier of cyberspace, it is logical that the Chinese Communist Party would want to invest heavily and take a leading role in technology to better defend its own sovereignty, rather than have another nation take on this role. From an economic perspective, China considers that taking the lead in metaverse technology will have a significant positive impact on their already rapidly expanding digital economy. The authors write in their start-up paper that the internet has "spurred an adjustment of economic structures and a transformation of economic development methods, giving a new impetus to the economy and society." Harnessing this momentum and leading a meta-digital transformation could have an incredible impact on China's economy. If the metaverse is the next phase of the internet, then whoever leads it could reap huge benefits from the billions of potential users.

4. Realized "battlespace"[10]!

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[10] or battlefield

It is clear from the previous chapters that China's leadership in the application of artificial intelligence is unquestionable, so it may be worth looking at their specific views on the potential for military use of the metaverse. In an article entitled "Looking Forward to Battleverse" in the late January 2022 edition of PLA Daily, the term "Battleverse" has already appeared in the article to emphasize the importance of military applications. In addition to emphasizing the potential for training use, an important fact is that there is no mention of further necessary technological breakthroughs. The predicted scenarios all use current VR/AR/MR and digital technology. Let us take a point-by-point look at the technical conditions needed to make the "battlefield" work:
    - independent network;
    - independent communication;
    - authentication security (strict access filtering process, recording of all operations of the elevators);
    - assignment of user levels (trainers, examiners, staff officers, system operators and maintenance staff, etc.) to access;

- artificial intelligence bots to assist individual users;
- realistic simulation performance (aiming to reproduce the functional performance of real weapons and weapon systems);
- creation of a realistic environment (geographic, electromagnetic, meteorological and hydrological environment).

The combination of these conditions can provide an opportunity to make better use of virtual space in military training. A summary of the potential benefits for military training and military-style education:
- The „battle room" will play an important role in centralized military education, allowing free communication with teachers and students regardless of location. Virtual teaching tools will also improve teachers' ability to explain new concepts.
- The „battlefield" can be able to fully meet the actual combat requirements of a large-scale operation. Repeated training and assessment help to improve tactical cooperation and combat morale of soldiers.
- The new weapons can be tested in simulations to assess performance, compatibility and overall combat effectiveness. (This can also increase the life span of conventional weapons.)
- The „metaverse" coordinates expert resources regardless of their physical location. A platform for remote extraction and control of new equipment and innovation in tactics. Conduct continuous analysis and acquire vast data sets for analysis and research objectives.
- If the usual means of command communications are destroyed in a confrontation, the „battle space" can even act as a backup communications system.

An important form of use of the „battleverse" is therefore the training of soldiers in actual combat conditions, for which virtual reality simulations are used. This is cost-effective and allows for significantly more training. Let us look at a Chinese example of the latest application of this type of training. The Chinese People's Liberation Army (PLA) has introduced a VR parachute training system for new paratroopers. The program uses spatial positioning, virtual simulation and other technologies to build a realistic skydiving environment, allowing new skydivers to detect various aerial emergencies, thereby reducing the risks of actual skydiving. All VR jump data is collected to help teams train most effectively. The result is that the simulation improves the training level of paratroopers, while also providing them with a platform to experience new paratrooper types, unfamiliar environments and new training subjects, which can greatly help paratroopers adapt to different battlefield demands and improve their skills.

Of course, the competition between the United States and China can be traced not only in the field of artificial intelligence but also in the application of VR. Although the US does not use the word „battleverse", it is clear that it has similar views on the

benefits of a military metaverse. The idea of using virtual worlds to prepare soldiers for war can be traced back to the 1980s with SIMNET, a large-scale network of various vehicle simulators and displays for real-time distributed combat simulations. (Tanks, helicopters, and planes on a virtual battlefield.) In recent decades, the standard for distributed interactive simulation and high-level architecture to perform real-time, platform-level wargaming has been developed on multiple hosts. Since SIMNET was a network simulation, each simulation station needed its own representation of the shared virtual environment. The demonstration stations themselves were mock-ups of certain tank and aircraft control simulators and were set up to simulate the conditions of an actual combat vehicle. Tank simulators, for example, can accommodate a full crew of four to increase the effectiveness of training. The network is designed to support hundreds of users simultaneously. The fidelity of the simulation was such that it could be used for training for mission scenarios and for tactical rehearsals of operations during US operations. SIMNET was actively used by the US Army for training primarily at Fort Benning, Fort Rucker and Fort Knox.

The SIMNET-D (Developmental) program used the simulation systems developed in the SIMNET program to conduct experiments related to weapon systems, concepts, and tactics. This became the Advanced Simulation Technology Demonstration (ADST) program. In the military branches, this type of technology is used to prepare soldiers for combat. Recently, the US military's newest branch, the Space Force (USSF), has described investment in the metaverse as key to their success. Recently appointed Space Force Chief Technology and Innovation Officer Lisa A. Costa stated on the first day of the Armed Forces Communications and Electronics Association (AFCEA) "Space Force Information Technology Day" in February 2022 that the USSF must "take advantage of what industry has of the investments made in the metaverse. These technologies could be used for training and operations, and when integrated into the digital engineering ecosystem, operator feedback could be used to automatically improve the product during the next iteration."

Conclusions

The metaverse is an emerging technology, so it is difficult to gauge how it will affect society, politics, economics, international norms, national security, and society as a whole. We are on the brink of a technology that can touch billions of users simultaneously, transforming how society consumes media and interacts with each other. In this article, we have summarized the concepts that will come to the fore when we examine the possibilities of military use of VR technology. Of course, we do not yet know what the future will bring. However, it is certainly worth further investigating the role of the metaverse in military training and education - the article primarily deals with this area - since it cannot be a coincidence that the two leading superpowers in artificial intelligence research (China, USA) also provide significant resources for virtual " battlefield" for research.

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