Virtual Combat Training: The Role of VR in Enhancing Martial Arts Practice and Education

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Abstract

This paper focuses on the utilization of the relatively new technology – virtual reality or VR as the approach to practicing martial arts. The advancement in body capture, physics simulation and natural interactions from the VR has enabled the training of high intense martial arts with little form but focus on skills. We foresee, the use of VR as a motivational tool and more importantly, for martial art practitioners at all levels, providing a safe environment to practice required and desired techniques, strengthen the required motor skills and develop the required situation awareness through replication of battle and customized training programs. In a more elaborate way, the use of virtual reality when practicing martial art makes it possible to record, evaluate and optimize the practice performance from various angles thus making the practice more enhancing. In addition, categories as different as martial artists or practitioners with various goals may benefit from VR applications that can present different levels of fighting simulation and, simultaneously, visual fighting stimuli of any size. The research involves positioning of the recent literature and case studies outlining the advantages and/or disadvantages of using VR in martial arts with emphasis on the feature of price, availability, and nausea of which the last one if unique to VR. Analyzing the data in the present there is no sign that VR would eventually replace traditional pedagogy but it appears to be a very good supplement to it and widen the circle of individuals who may find martial arts applicable opening doors for VR to be used more often as training tool for other skills-based activities as well.

Keywords: VR, Virtual Reality, Martial Arts, Technology, Education, Arts, Augmented Reality, Body Tracking, Physics-Based Simulations, Personalized Training Regimens, Customizable Practice

1. Introduction

Virtual Reality now widely being used as a game changer in the fields of education and sports. For instance, VR puts one in active learning trying to expand their practical skills and knowledge rather than just memorizing. It is hard to imagine how history or science classes would be motivating without VR. Thus, VR opens up new horizons of imagination and changes traditional paradigms. VR applies to martial arts in a way that has never been seen before. It wed the interactive sensations of immersion and performance. Learning places them inside simulations where they can perform a moves, critique their own performance, and even fight against fake opponents. This reduces the risks associated with combat but allows them to focus on accuracy and skill acquisition. In addition to motion skill, VR promotes self-teaching. Individuals can learn and practice techniques that require analytical skills and decision-making freely and independently. This feature combined with the attention-grabbing nature of VR allows even uninterested learners to actively participate and enjoy learning. Technology has its limitations in that VR can be costly, requires equipment and it is difficult to find the right mix of real-life and VR practice. However, there is great hope in that technology is evolving quickly and one why the time comes, VR will be simple and effective where it can be completely integrated into various sectors maximizing the opportunities presented to transform the way individuals learn and grow.

2. Research Objectives

- Taking the literature to distinguish basic concepts such as virtual reality and augmented reality, defining all such types of technologies around their meaning, conceptual meaning, and technical foundation.
- To analyse the various structural elements that are applied in the development of VR, with focus to the products like Unreal Engine and Unity and the part they play in the developer's creation of engaging virtual spaces.
- For the purpose of analyzing possible uses of VR in learning and to demonstrate how VR can be used to supplement instruction by making learning activities possible in virtual environments or by using VR-created activities to teach lessons.
- Assessing the advantage of using virtual reality technology, which is, improved immersion and interaction, against the disadvantage which are cost of the hardware and health effects.
- The focus is to the search selectively and purposefully for various illustrations and practical experience of the application of VR technologies in such fields as games, health care, training and the like for the purpose of demonstrating that VR is able to resolve the issues of industry and even transform them.

3. Literature Review

This research is informed by several studies investigating how immersion technologies augmented and virtual reality converge, especially within the framework of education and martial arts training perspective. "Incorporating immersion technology in martial arts," Pu and Yang in their work "Application Of Virtual Reality Technology In Martial Arts Situational Teaching," seek ways in which martial arts education can integrate virtual reality. They show how VR can be used to simulate real life fights thus enhancing education by providing a safe and controlled environment. To this concern, in their paper "The Use of Immersive Technologies in Karate Training," Lygouras and Tsinakos focus on the introduction of virtual reality and other immersive technologies in karate practice. They stress the fact of invulnerability of reality through its high definition

accuracy in the immersion which in turn improves one's tact/course of action. VR and AR in the Classroom. Al-Ansi et al. probe the possibilities of the new AR and VR technologies in education. In their analysis, these technologies are increasingly gaining recognition in the interactively-connected learning paradigm, where students with the help of three-dimensional materials are able to grasp and recall specific information within a specific context. McCarthy et al. describe the factors that are vital for educational leaders in technology integration to be successful in their vision of digitalization. They advocate that in order for teachers to successfully execute the use of rather complex VR technologies in the classroom, they have to understand these issues comprehensively. "Learning Theories and Educational Integration" For the past ten years, Marougkas et al. have provided a decade's worth of insight into the learning theories, methodologies, and techniques employed in VR education. They address the issue of how to assist pupils with VR technology and to resolve its limitations through distinguishing unique learning preferences. Lege in Bonner, can't escape the call to write an article 'Virtual Reality in Education: The Promise, Progress, and Challenge: What Do Teachers and Students Think About the Barriers of VR-based Learning'. On the contrary, they do highlight that while virtual reality has immense scope in creating effective immersive learning spaces, cost, accessibility and teacher preparedness remain significant barriers. The literature points towards the growing penetration of VR in various industries, discussing its pros and cons. Despite the fact that the technology's rapid advances can be seen, its application in such niche areas as general education and martial art depicts how versatile and disruptive it can be.

4. Methodology

The study employed a literature review, a number of interviews and activities aimed at observing the level of using VR and AR technologies in education and training. A set of selected reports were scrutinized to gather some information on advantages, barriers and application of virtual reality. Practical Unity development was focused at effective practices, and the comparative study presented how useful VR is in

the study and training of martial arts. The information was then integrated in order to develop useful suggestions for educators as well as for developers.

5. Basic Concepts

5.1. Virtual Reality (VR)

Virtual Reality is a pressured encapsulation involving a mediated 3D environment, sync with 3D visuals, sounds and sensory touch, while sensory elements are attached to the customer experience to improve positive connotations. In contrast to movies, TV and other media that are more passive and didactic, VR is highly engaging because it allows users to interact and influence the environment around them. According to Sean Keller (2023), the user experience is facilitated by headsets that also monitor head and hand movements allowing users to feel their presence in the virtual reality. VR has applications in entertainment and video games, but also in education, health, and professional training. The technology recreates complex scenarios and environments that cannot be practically replicated in the real world because of time, danger, money and other factors. One major benefit to emerge from this type of education is that the VR environment is totally immersive. Effective sensation maximization enables users to safely and effectively examine and perform movements of interest in an artificial but controlled environment. The feature is desirable especially in education and skill training where students can engage with computer-generated environments, perform the procedures, and get feedback immediately without the need to risk any live situation. VR is one technological advancement that has a lot of advantages in the training and teaching field. To start with, VR improves content accessibility as one has the ability to carry out practice in a more engaging way as compared to books and videos. Also, the risk of practicing high risk activities like combat training is there but risk of real exposure to danger is non-existent. This makes it suitable for learning complex and dangerous skills. VR is cheap compared to other traditional methods of training as it cuts down issues of physical props and real space or expensive materials, therefore making it suitable for diverse training programs. On top of that, research has indicated that increased effectiveness is observed with VR due to 37.6% of respondents indicating that they prefer VR programs because their effectiveness in learning is greater. To finish with VR promotes learning and interaction at a distance, it presents a number of conveniences such as virtual trips, telemedicine as well as distance learning. Where learners interact in interesting scenarios in an active virtual world and get experiences that are otherwise inaccessible. Like any other technology, VR comes with a number of drawbacks. One of the most pressing is the price of VR hardware and software, which is extraordinarily expensive. Even though the prices are on a downward trend, VR systems are so costly that most individual consumers and organizations tend to shy away, thus curtailing mass acceptance. There are also, however, technological constraints. Some of the most common complaints about current VR systems are narrow field of view, low resolution, motion sickness and latency, all of which have a negative impact on user satisfaction. Then again, physical discomfort is equally another disadvantage – for some users, excessive usage of VR bankrupts them of energy and comfort leading them to either restrict the amount of time for the sessions or rendering them unenjoyable altogether due to the feeling of nausea. Another restriction of VR is that it does not provide complete immersion in terms of the use of body language and physical contact typical in real life. Even though environments can be convincingly rendered with VR, tactile feedback and subtle details that are indispensable in some applications are not yet rendered, which limits effectiveness of VR in these applications. Last, there is the adoption costs associated with the user, especially the technologically illiterate ones. Operating in VR environments can be challenging, and it may take some time for some individuals [1].

5.2. Augmented Reality (AR)

Augmented Reality enhances our perception of the world using a smartphone or AR glasses by overlaying virtual images, pieces of information, or sounds onto it. Being different from Virtual Reality that isolates users in isolated simulated worlds, users can hence work with 3D virtual objects within their own physical setting using AR. Therefore, AR

changes the way a person perceives the immediate environment by substituting or embedding extra layers on top of them. AR enables the development of better tangible experiences yet does not remove the user from the physical universe. The influencing of the digital content on the physical objects, thus, introduces a completely new way to perceive and experience the world. For example, augmented reality supports the buyer of shop furniture to see the kind of furniture that will fit into living rooms before buying, and the classroom environment allows textbooks to be supported with 3D models or animated scenes maybe. Augmented Reality is one of the emerging technologies in a rapidly growing field, and different industries such as healthcare, gaming, entertainment, retail, and education among many others are witnessing big impacts. This enriched presence makes way for many more opportunities by providing better quality experiences to users, efficiency, and new solutions. As the technology and applications around it are becoming increasingly defined, in the near future, AR will change the way we go about living our lives related to how we interface between our physical and digital worlds.

AR and VR are two transformative technologies that change the way we experience reality, yet both present interesting, separate qualities. Though they offer an immersive kind of setting for experiences, they differ regarding their working, gadgets used, way of interaction, and scope. This dictates an understanding in maximizing their potential in education, healthcare, gaming, and retail [2].

6. VR Development Overview

Developing for Virtual Reality, is revolutionizing environments we will all interact with and experience digitally. By generating virtual reality worlds with hardware and special software developers can create exciting interactive worlds. Unity, one of the most ubiquitous game engines, makes VR development a lot easier. Its is provides various tool and resource to help developer from beginner to expert in VR games, simulation or application development. The VR-specific components within Unity allow you to cut through the clutter and quickly go from an initial vertical slice to a polished product.

- **Major Steps in Unity VR Development:**

Creating VR experiences in Unity generally follows several important phases, each key to making an exciting and immersive product.

- **Project Setup:** With its easy setup, Unity enables developers to get into VR at a moment's notice. DevXO by adding integrated plugins XR Toolkit to make Unity outputting many variant VR platforms such as Oculus, HTC Vive or PlayStation VR. VR camera system tracks user movement for an inside the virtual world view.

- **Interaction Design:** VR Interactions, Unity's XR Interaction Toolkit provides a set of components for common VR interactions. The functionality features also enable the developer to easily create grab, teleport and pointer implementations that are a key aspect of VR Interactions in general. These types of tools were created within a framework to enable users to interact and explore the virtual with an ease that feels nearly natural.

- **Game Environment Creation and Mechanics Design:** In this stage, game developers implement the environment by inserting interactive features such as 3D models, colliders, and triggers. These actors' scripting opportunities also enable real-time interactions, including object manipulation, gameplay event incidence, and other diverse manipulations. This level of interactivity increases the penetration because the medium becomes more animated and responsive to the user's movements.

- **Incorporation of Video and Sound Effects:** VR experience just cannot do without sound and visual components. The sound design can be intensified by using Unity's spatial audio components, which allows placement of sounds within the 3D environment so that viewers can hear them from a specific location of the events taking place in the scene. If the visual design of the site is done properly in terms of overall style, lighting, and textures, then the user will be able to adequately perceive the virtual reality environment.

- **Publishing:** Once the VR experience is

completed, the Unity has the capabilities to render the project suitable for many VR platforms. Developers must adhere to some requirements of the specific VR store, which may be the Oculus or SteamVR, among others, for the experience to be usable by the end user. With these guidelines, the content is expected to be well optimized.

- **Challenges & Opportunities:** Although Unity has taken measures to ensure that abusers friendly features are available, some difficulties are still encountered while developing in VR. The lack of optimization in hardware is quite stark, considering that VR experiences are intensive and require high performance. Also, ensuring that users are comfortable is essential to facilitate their experiences as motion sickness might be an issue. Designing interactions that feel natural and quick to respond to is still a problem. But as the VR hardware keeps improving and so does the variety of possibilities with Unity's ever-expanding toolset, new possibilities are being presented. Developers have the capability of implementing interaction with AI, using realistic physics engine, having complexity in the created Virtual environment. These enhancements will significantly expand the scope of VR, opening opportunities for applications in gaming, education, training, and many others. While Unity is relatively easy to pick up for those new to VR development, it is also rich in features that experienced developers will appreciate. It is possible to develop numerous entertaining and vivid VR environments with the help of their solid package of tools. As the industry matures, so will the compassion of the creators, allowing even more great and sophisticated virtual reality settings to be built with the help of Unity.

7. Result

7.1. Virtual Reality in Education

In technology, progress has been witnessed almost in every field of human knowledge; education is no exception. It is almost impossible today to grapple with any news broadcast without confronting the words "Virtual Reality" or "VR." For the ignorant of the term "VR," it could be described as a simulation created by a computer permitting users to interact with a three-dimensional reality. This technology has gained wide acceptance in educational institutions, and some have even created proprietary systems for local use within their respective boundaries. Considering the precision and further comprehension that VR has for a student in any field, has schools everywhere adopted them? You are sitting in an ordinary classroom with colored walls, and posters hung from the back. There are other students in the room and a teacher which seems somewhat energetic, bald and is standing at the front, but honestly the room is burning due to the summer heat, right, so any pupils attention is quite limited. What's your go-to, for avoiding having to take notes while the noise of other students drowns out the teacher's voice. Conclusion: It's more focused, and easier to deal with other students. I do not think that sounds reasonable. Then In the beginning most people in the world have not been impressed with the advancements in technology ever since the human came into this existence, but only a handful were confident that it would definitely shape the world, with a shift particularly caused pop-Culture. Today the entire world is talking - and now literally everything, hundreds of influencers alongside with artists and school's university everywhere is promoting how easy integrating VR into any classes sounds. Some schools have already adopted the use of this technology while others are still doing research to implement the use of VR in their curriculums. One example is that by 2025 most curriculums would have an integrated VR program. Students are likely to benefit greatly from the usage of this technology due to the various advantages that VR offers. Students are more focused in class, acquire better moral values and design, and the learning process becomes much easier and more fun. VR in education provides a highly immersive, interactive platform that can bring abstract concepts to life. It allows students to experience simulations of historical events, conduct science experiments, or even explore distant planets. It has benefits in education such as holding knowledge, catching attention in a more inclusive

manner, and experiencing things that would otherwise be hard to gain. However, there are still problems included such as high costs of setting up, accessibility, and the need for special training which yet remain as trudges in the adoption of VR in classrooms [3].

7.2. Virtual Reality in Martial Arts

Virtual Reality has a use in the discipline of martial arts by improving training techniques; it allows practitioners to conduct 'battle' simulations in controlled, and monitored conditions. The VR system allows participants to simulate battles realistically and under the exact conditions of 'real warfare'. In these virtual environments, techniques are perfected, response times honed, and strategic approaches envisioned without the need for real-life opponents. The benefits of martial arts training include the opportunity to repeatedly practice movements, the capacity to concurrently assess performance, and enhancements in safety when conducting training sessions. However, there are some cons associated with this technology: a lack of haptic feedback and thereby less realistic experience and the fact that the equipment required to simulate can be highly complex. The advent of Virtual Reality is significantly transforming the methodology of martial arts training, presenting immersive settings emulating authentic combat scenarios. Advances in VR technology allow martial arts practitioners to hone their skills, perform simulated sparring exercise with virtual antagonists, and build their competencies in an entirely safe and controlled framework. This paper discusses the prospects of VR for the training of martial arts, exploring immersive sparring interactions as well as purely physics-driven simulations and the associated benefits and difficulties. VR allows the martial artists a new way of training by mimicking real combat conditions sans the risk of physical injury. By involving themselves in VR training, martial artists sharpen their techniques, increase their reaction time, and improve their endurance in a controlled environment. Engaging with other attackers or perfecting their self-protection techniques, virtual reality makes it possible to build the necessary skills that will be cultivated in various disciplines of martial arts. The extensive body tracking with physics-based simulations places the interactions developed with opponents in a more realistic experience. The actions, strikes, joint manipulations, or grappling techniques set into place by the user generate tangible effects on the virtual opponent. On the other hand, this advancement builds an environment for virtual reality sparring that is highly participatory and responsive, substantially improving the quality of training. Virtual opponents can give immediate feedback from the techniques adopted by the practitioner, which helps change their strategy according to any situation presented. Virtual Reality (VR) poses several limitations in the context of martial arts training. Perhaps the greatest concern is the absence of haptic feedback, since VR technology can not simulate the sensations associated with impact or resistance, thereby limiting the progression of skills like timing and control. Furthermore, a substantial number of users feel liable to motion sickness or discomfort very often, especially when the scenes are fast-paced or very immersive, and this could dilute the effectiveness of the training session and discourage longer periods in the program. Premium virtual reality equipment, such as headgear, motion sensors, and matching computing machines, is too pricey for most martial artists or training centers to afford. Being potentially augmentation-able of skills and visualization-simplifying, these concerns hence do come across that it is not yet a fully adequate replacement for experiential training in real-world contexts [4].

7.3. Real Word Scenarios

In the martial arts training, physical contact in 3D immersion environments is made more feasible by the use of virtual reality (VR). With modern virtual reality technology, practitioners can effectively engage their opponents, perform secured locks, and spar in computer-generated environments. They can be realistically depicted including a street brawl or a sports arena during a match. By using such an inventive method, it fosters skills training as it provides an effective innovation on training which integrates realism and effectiveness. However, as tempting as it may seem, there are some difficulties and aspects which need to be dealt with in the use of

VR specifically in martial arts training [5].

7.3.1. Immersive Boxing and Martial Arts Experiences in VR

Removing most of the sense inputs found in VR headsets allows martial artists to train without fearing they may harm themselves or other people in the process. Students may mimic every gesture and movement possible to their heart's content without having to worry about a trip to the emergency room. When it is self-defense or an improvement of techniques against multiple numbers of individuals, VR enables the subject to focus on different features in the course of different forms of fighting and combats. Primarily, serious consideration will be given to entertainment aspects of VR-based martial arts games; however, it will be important not only to encourage the audience to join the game but also apply certain strategies and tricks during the contest. Everything about an immersion experience is possible in live situations it is possible to try martial artists' reaction, their impulse, or their decisions and their versatility to the greatest extent possible. Using such a high level of immersion in the virtual world facilitates feeling trainings that would be conducted far more appealing and effective than other training methods. With these gestures, users can touch the virtual opponent in the game by punches, throws, grabs or even submit a virtual opponent. This enhances the training experience to VR sparring as it becomes quicker and far more engaging. Two averaged computer player models and give real-time feedback and enable athletes to change their skills. With VR systems, training opportunities can be presented in a form that can be modified to the learner's experience levels. To improve co-ordination, timing and combination patterns users can for instance change the frequency of the sparring, act against the moves from several partners, or execute specific exercises. Martial artists can reflect on their techniques and track their progress using performance capture which offer data on aspect that needs enhancement.

7.4. Limitations and Challenges of VR Training

One of the major disadvantages is the lack of haptic feedback. The blow and physical resistance with which the enemy offers are crucial elements in coaching for actual combat. Although the virtual reality can simulate the actions and the outcome, it is not comparable to real conflict in terms of sensations which might actually bound the transferability of the skills acquired into the actual combat environments. This may be due to overexposure to virtual reality, perhaps when the users experience complex combat maneuvers, rapid movements, or rotational actions. This can limit the training duration and period in VR, especially in first-timer user or those who require a longer time to adapt to the simulation performed under VR. Premium virtual reality systems are, even so expensive especially in the cases of wireless headsets and wide body tracking. This, therefore, implies that small dojos or users may not easily acquire premium virtual reality systems. All this notwithstanding, a high cost has prevented this technology from being reached by most users.

8. Discussion

8.1. Future Potential and Advancements in VR for Martial Arts

Arising interesting possibilities that the new technologies in martial art training might introduce, virtual reality has the potential to transform martial arts instruction radically as it matures to more realistic, immersive, and personalized activities. Future enhancements may include advanced motion tracking, better haptic feedback, and AI-driven opponents in creating a highly excitatory and dynamic training environment. These may make high quality training more accessible and enable practitioners, in their own time, to achieve more perfect technique with fewer accidents. Virtual reality also has the power to overcome the logistical and geographical barriers that will allow martial arts communities around the world to collaborate and learn together. For general availability, lighter, less costly systems need to be developed. VR training sessions will become even more immersive and enjoyable with the rise of wearable technology. Haptic feedback, which would simulate actual contact, adds a level of realism: for instance, martial artists are able to feel the effect of an impact while training. The VR world of martial arts instruction stands at the brink of a revolutionary change since

artificial intelligence is now being integrated ai-powered opponents could adapt to the skill of the user to produce dynamic variable sparring experiences this would ensure that training challenges never become boring and martial artists continuously improve and hone their skills the adaptive opponents would also provide a much more complex scenario than users could train for thus better preparing practitioners for real-life combat situations. An excellent training plan would combine the old-school, face-to-face martial arts instruction and the virtual reality training. While VR potentially can enhance technique, face-to-face training and sparring are still necessary to fully understand combat dynamics. The safety and adaptability offered by virtual reality training and the practicality of real-world application might afford martial artists the advantages of both modalities.

8.2. Technological Advancements

Technology in VR is not stagnant; it is evolving, and with flying colors, at that. Increased graphics, computation capabilities while AI technologies are being created – all of that enhances VR. In martial arts training, and other similar trainings, the incorporation of haptic feedback like motion and hardware sensors help the users to feel some types of mixed feelings during trainings, making the training even more natural. Moreover, its use allows to develop a strong training system using the approach of delivering a meaningful individual training in accordance with user activity [6].

Conclusion

It has huge potential to revolutionalise the way that martial artists of all calibres practice their art, it is not just a passing gimmick in martial arts training. Engaging in the environment built with the help of VR devices, a practitioner involves physical laws in combat training, gets rid of a number of restrictions, adapts to situational conditions, and finds new approaches and solutions which cannot be obtained in conventional training methods. To do this, VR is an indispensable platform since within the highly configurable virtual opponent environment, the martial artist literally gets to maximize a learning experience as action and learning can be captured from many points of view. Yes, the virtual reality can imitate only some aspects of a live sparring session, but it has many advantages: a possibility of practicing intensive techniques without possible injuries, a free space to work, an opportunity to practice alone with individual pattern. There are still challenges: the cost being the expensive technology, motion sickness and lack of haptic feedback. But as we speak, these barriers are coming down due to improved technology and hence making virtual reality more affordable and effective. Thus, we provide evidence that virtual reality is a powerful supplement to traditional training, but not a replacement for it. Thanks to easy availability, versatility and the geographical limitation, martial arts education is available to a larger audience. So, as the advancement of virtual reality technology continue to progress in the future, virtual reality class will integrate with in-person class training medium to offer the interoperability of the best training. This blends the information of old with the innovation of the new to give martial artists a more enjoyable and gratifying path to achieving black belt status.

References

[1]. Application of Virtual Reality Technology in Martial Arts Situational Teaching, by Yuefeng Pu1 and Youhong Yang2

[2]. The Use of Immersive Technologies in Karate Training: A Scoping Review by Dimosthenis Lygouras1 and Avgoustos Tsinakos2

[3]. Analyzing augmented reality (AR) and virtual reality (VR) recent development in education by Abdullah M. Al-Ansi1, Mohammed Jaboob2, Askar Garad3, Ahmed Al-Ansi4

[4]. Digital transformation in education: Critical components for leaders of system change by Aidan Michael McCarthy1, Dorit Maor2, Andrew McConney3, Cathy Cavanaugh4

[5]. Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade by Andreas Marougkas1, Christos Troussas2, Akrivi Krouska3 and Cleo Sgouropoulou4

[6]. Virtual reality in education: The promise, progress, and challenge by Ryan Lege1 & Euan Bonner2