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Role of Virtual Reality, Augmented Reality and Mixed Reality in Physical Education and Sports

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Abstract: ***Virtual reality (VR), augmented reality (AR) and mixed reality (MR) technology are being increasingly used by athletes, coaches, and other sport-related professionals. VR, AR and MR provides additional information to the reality of sport people, and might offer supplementary advantages compared to other technologies. The goals of this study were to characterize and understand the benefits of these realities in sports education ,training and applications. Future directions are discussed.***

Keywords: Virtual reality (VR), augmented reality (AR) , mixed reality (MR) and Sports

1. Introduction

The application of computer-based technology to sport is an area of intense interest. Such technologies include computerized modelling, data acquisition and analysis, mobile computers, and information technology networks . Virtual reality (VR) is another technology, and it was first applied to support research in the 1990s, although there has been a resurgence of interest in recent years. VR refers to a computer-simulated environment that aims to induce a sense of being mentally or physically present in another place (1-2). An important feature of VR is that the individual can interact with the environment. In the context of sport, interaction might occur through an exertion interface (3). For example, physical effort on a machine such as an ergometer can be related to the speed of movement through a virtual race course. Motion capture video systems, infrared beams, and wearable sensors are other approaches that can be used to translate physical actions into virtual sport performance (4).

The key elements that define VR applications to sport are the use of computer-generated sport-relevant content and a means for the athlete to interact with the virtual environment. When defined in this way, the application of VR to sport has a number of strengths. As noted by Hoffman et al. (5), the VR environment can be controlled and manipulated in specific and reproducible ways. Hoffman et al. used these characteristics to train participants to use a rowing race pacing strategy. VR can also be used for assessment, to gain feedback on performance, and to practice specific skills. The VR environment does not need to be limited to a single person. Other individuals may be present such as a coach, teammate, or competitor even if they are physically located in another place. The ability to connect with individuals via the Internet allows for interaction without the need for travel. Finally, the increasing availability of commercially produced software or full VR systems avoids the need for specialized technical expertise and allows VR to be used in local gyms and at home(4).

AR is within a more general context termed Mixed Reality (MR) (6), which refers to a multi-axis spectrum of areas that cover Virtual Reality (VR), AR, telepresence, and other related technologies (7).

Virtual Reality is a term used for computer generated 3D environments that allow the user to enter and interact with synthetic environments (8-10). The users are able to "immerse" themselves to varying degrees in the computers artificial world which may either be a simulation of some form of reality (11) or the simulation of a complex phenomenon (12-13).

The history and future of virtual reality in physical education and sports:
As early as the 1930s, science fiction writers, inventors, and tinkerers dreamt of an environment where you could escape from reality via art and machines. We were weighing questions about Virtual Reality vs. Augmented Reality vs. Mixed Reality long before we had the technology to make them possible.

Technology has caught up in fiction, and market researchers predict rapid growth for the VR industry as well as in sports.

VR, AR and MR
First things first, let's define the terminology. Virtual Reality can be used as an umbrella term to describe other technologies similar to, but different from, an actual Virtual Reality experience. But what's the difference between Augmented Reality and Mixed Reality? Here are some more details:

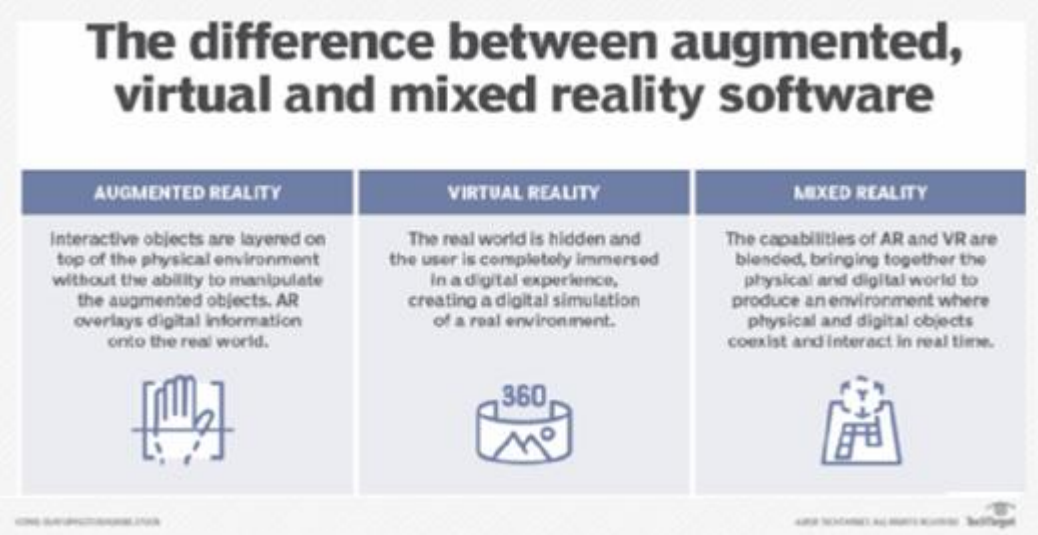
Virtual Reality
VR is the most widely known of these technologies. It is fully immersive, which tricks your senses into thinking you're in a different environment or world apart from the real world. Using a head-mounted display (HMD) or headset, you'll experience a computer-generated world of imagery and sounds in which you can manipulate objects and move around using haptic controllers while tethered to a console or PC.

Augmented Reality
AR overlays digital information on real-world elements. Augmented reality keeps the real world central but enhances it with other digital details, layering new strata

of perception, and supplementing your reality or environment.

Mixed Reality

MR brings together real world and digital elements. In mixed reality, you interact with and manipulate both physical and virtual items and environments, using next-generation sensing and imaging technologies. Mixed Reality allows you to see and immerse yourself in the world around you even as you interact with a virtual environment using your own hands—all without ever removing your headset. It provides the ability to have one foot (or hand) in the real world, and the other in an imaginary place, breaking down basic concepts between real and imaginary, offering an experience that can change the way you game and work today (14).



Source: (15)

Milgram and Kishino (16) have positioned the augmented reality in a place in the middle of virtual reality and real world. To sum up, augmented reality is submitting the information or message which is desired to be delivered to user with the help of various technologies in a way where the real world perceived via our senses by enriching with external images, sounds, data and information to the simultaneous user. Thanks to this way, the perception of a different, enriched and attractive world is created by redesigning the real world (17).

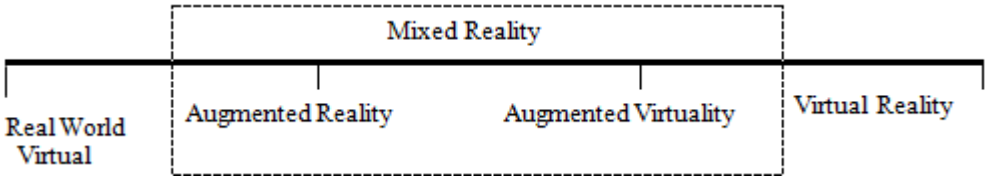


Figure 1: Milgram's reality–virtuality continuum (Milgram & Kishino, 1994)

What is AR /VR?

Point of Difference	Virtual Reality	Augmented Reality
Nature of Digital Environment	A fully digital, artificial environment	. A digital and artificial environment, only partially in the backdrop of the naturally existing environment.
Means of Operation	A virtual and computerized artificial environment, distinct from the real environment.	Over-lays or superimposes virtually and computer-generated objects and graphics on real world environment.
Effect	Creates a separate virtual existence which operates in absence of reality dimensions.	Allows interaction between artificial objects and real world entities in a natural setting.
Impact	Immerses or engages the user entirely in the virtually created digital atmosphere by detaching him/her from the natural environment.	Only enhances the observation, experience and understanding of the real world by using visual objects and addition of artificial smell, sound and graphics.
Quality of Display Device	Use of highly sophisticated computerized technologies in creation of heavy graphics and virtual objects.	Only adds virtual objects to existing natural world view, requirement of the quality of graphics is low.
Device	HTC Vive, Oculus Rift or Google Cardboard.	Pokemon Go, Snapchat Lenses, Google Glass.
Illustration	Virtual recreation of a historic era to enable better understanding of the past for students.	Projects a busy road with superimposed virtual signs indicating shops, petrol outlets nearby.

Source : Augmented, Virtual and Mixed Reality – A Reflective Future
https://dms.nishithdesai.com/work/link/d/WORKSITE!522609.

Virtual Reality Concepts

Creating a virtual environment is a necessary component of the virtual reality, it is the one that brings us to it, we see and we will be in the world, such as what exists in real life. These are the functions in which the computer is installed and where the software is not allowed to run. 3D models and real-world experiences of the environment. These functions will be used by special programs that have the ability to control their data. Visualization of the three-dimensional feature on the computer screen (or more often than on the screen) or on the screen of a larger screen like this used with projectors overhead. This may be due to the use of special monitors. Treat them and give them the appropriate responses. It is also possible to use the audio codecs that can be switched off. Tools used in the virtual reality: (18) 1- Visualization 2- Projectors & Displays 3- Head Mounted Display 4- Navigation 5- Equipment Driven 6- Equipment Mounted 7- Touch &Control 8- Grasp 9- Position Tracking 10- 3D Sound.

Applications of Virtual Reality in Sports

The entering of virtual reality into sports is no longer a question of if, rather a question of when. In the near future, expect to see aspects of virtual reality gradually transforming the way you enjoy your favorite games. Here are some of the most interesting things that are happening in the space today.

Virtual Reality Sports Training:

VR has seen use in training surgeons, fighter pilots, and construction workers. Today, it is also used to push our professional athletes to the furthest heights of excellence. Virtual reality firm EON Sports specializes in creating virtual training environments for athletes. Using both commercially available and custom-designed head-mounted displays, Eon places athletes on the field virtually. By leveraging the power of a computer simulation, Eon's solution presents a unique opportunity for athletes to practice against their actual opponents. Eon programs their simulations with data on opposing teams' style and performance, custom-building a training regimen for the needs of each athlete. Users stand in front of a green screen and hold physical equipment, such as a baseball bat, to interact with the simulation. Avoiding impacts and injuries during training means healthier, safer athletes who are in top fighting form when game time comes. Simultaneously, confining the action to a computer simulation means that every action and reaction can be shared by coaches and specialists, as well as recorded for later analysis (19).

The company takes an unusual approach to bringing fans into the game. Rather than planting 360° cameras on the field, Virtually Live instead places static cameras around the stadium, covering the action from every angle. Their software then creates a computer-generated virtual environment and streams it to viewers, who can move freely through the broadcast using their commercially available head-mounted displays. The sports match is recreated using CGI graphics, but the action is completely real. Virtually Live is in the startup phase and has not yet found widespread adoption in the United States, but the amount of press and media coverage the firm has received is promising. As a test, the company live streamed the FIA Formula E Championship, a car racing series exclusively raced by electric cars (20).

Augmented Reality Concepts

When the definitions given in the studies are taken into consideration; augmented reality can be summarized as the technologies developed for increasing the perceptions by transferring more information and data to people about the real world which they perceive through their senses. Even though people concentrate on these fields in recent years; the idea to increase the perception by benefiting from the technology depends on earlier times. The patent obtained by Heilig in 1962 is one the first augmented reality ideas. Through the device which is called as Sensoroma, Heilig thought of performing the scenes shown in movies by delivering the vibrations and smell with the sounds and images given in films. The concept of augment reality has been included in the literature by Caudell & Mizell (21). In their studies, they urged upon glasses to be used in the manufacturing of plains in a more complex form which is made by inspiring from the protective glasses used by the employees working in factories, to increase the efficiency, performance and the quality of conducting works. In addition, within their studies, they have stated that it is more appropriate to virtualize and process images at required amounts by assuming that a more computer process force and thus more costs are required because of operating the virtual reality in a computer environment after processing the real world as graphic at all. By noticing the importance of mobility in AR practices, the prototypes of especially head – mounted and wearable technology products started to be developed and be suggested (22-23). In this study, Mann (23) has developed a mobile AR prototype (MAR) which transfers the real three dimensioned images of a university campus by compounding it with information on a transparent screen by using the global positioning system. However, this MAR is not compatible for utilization because of its 11 kilos of weight and high cost. In today's world, thanks to the developments ensured in the field of micro – electronic; it has become possible to integrate the micro – chips having high processing power with smaller devices (24). The Mobile AR applications have become easy to develop thanks to cell phones, tablet PC's and moreover the smart watches and the GPS module which turns into a standard for glasses, the sensors for height, distance, etc. which can be integrated with AR. Eyesight is one of the most important sense of us without any doubt and it is possible to benefit from all the opportunities emerged by AR in every field where there is eyesight. However, it has been stated that there are more AR applications developed in five main fields, especially in smart phones as (i) sports, games and education (learning in entertaining); (ii) cultural heritage and tourism, (iii) medicine, (iv) education and training, (v) marketing (Adhani & Rambli, 2012). In the future years, AR studies will gain acceleration by submitting the smart glasses to end user and spreading its utilization (17).

Augmented Reality in Physical Education & Sports

The Hawk-Eye innovation, on the other hand, develops applications for managing the competitions in a fairer way and for being utilized by trainers ("About Hawk-Eye", n.d.). Thanks to the system developed especially for tennis, the

condition, whether the ball is within the tennis court or not can be determined and the referees can have right decisions through this way (Figure 2).

Learning sports skills:
Recent approaches are including perceptual learning methods to create more specific and robust training. Learners are exposed to several situations, allowing them to develop knowledge of different domains, which could lead to faster decisions (25). Although visual displays play the dominant role in communicating information to the user, they might be limited to providing stimuli related to features and events occurring in the direction that users are facing. Audio cues could provide additional information about the surrounding environment to the user. Tactile sensorial feedback such as texture, temperature, and vibrations may also serve as mechanical interfaces between our bodies and the physical world.

Figure 3: Hawk-Eye system in tennis (http://www.hawkeyeinnovations.co.uk/page/videos)

By using AR, both skill training and naturalistic sports scenarios might be executable at the same time. Technological augmentation could also reduce the focus on natural human abilities, and could emphasize the skills and abilities for harmonizing with technology (26). It also considers the players' competitiveness, PA, and entertainment. Witting (27) showed that it may not be necessary to include all the real sports actions into the gaming scenario, and athletes can still benefit from the gaming only by observation. Baumeister et al. (28) mentioned that limited fields of view (FOV) could increase cognitive load requirements, and special AR displays could increase performance and reduce cognitive load.

Providing additional information
The central aspect of using AR for imrproving sports skills relies on the possibility to provide additional information for helping users to decide and regulate their behaviors. In this case, artificial information is overlayed on the real situation to enhance the user's understanding and knowledge. It has been shown that offering additional information, especially to novice players (player balancing), might improve their experience, enjoyment, and immersion (29). For example, Sano et al. (30) projected players' positions to help beginners to improve their decision-making skills in football . Rogers et al. 29) projected icons, indicating boosts and handicaps, over table football to influence the game play and to adjust for different player skill levels. Kelly and O'Connor (31) developed a visualization tool for tennis that augmented information about technique, timing, and body posture. Players' movements were aligned and compared with an experienced player, and the results were projected on players' video recordings. However, no experimental evidence of the benefits offered by this tool was provided. Sodhi et al. (32) created a real-time guiding system that projected the hints directly on the users' hands. They showed that the participants could perform movements more accurately compared to guidance by video.

Providing additional feedback
Performing the correct movements in sports is important to achieve certain goals and to avoid injuries. AR systems may allow accessing additional feedback about performance and behavior. Frequent terminal (after task execution) and concurrent (during task execution) feedback are crucial for learning simple motor tasks, and could be supportive for complex tasks. Concurrent feedback helps to correct errors that might hinder learning. Additionally, concurrent visual and haptic feedback had better effects compared to auditory feedback. It seems that a combination of concurrent and terminal feedback would be most effective when the feedback strategy is adapted to players' preferences and skill levels. For effective verbal and visual feedback, Jeraj, Veit, Heinen, and Raab (33) developed a heuristic model of error correction, to identify six feedback factors of visual perspective, visual experience (visual gaze strategies when observing and judging the movements), motor experience, personal coach-athlete relationship, methodological knowledge, and biomechanical knowledge that might influence the error-correction process in gymnastics.

Stimulating practice
By increasing diversity of the movements and challenges, and enabling personalized content creation, digital augmentation can contribute to the improvement of sports performance. Previous research has shown that intentional use of some AR games can accumulate the recommended levels of daily/weekly PA (34). Additionally, Hsiao (35)

developed an AR learning system that combined learning activities with physical fitness, and showed improvements in players' academic lessons.

Enhancing customers' choice

Advances in AR can finally benefit sports customers as the technology can help practionners to project themselves in sport gears. Current works focus on the best way to shop sports shoes and look more suitable for meeting the fashion expectations of customers (36-38). One can imagine that in the near future, such features can help outdoor practionners to choose the filters of their sunglasses to understand whether they are suitable for marine navigation. It can also help customers to choose their ski by watching the expected carving trajectories of a specific model.

Figure 3: Providing additional information to sports scenes might improve viewers' experience and help the referee's decision-making

Introducing new rules and creating new sports

AR allows introducing an additional virtual layer that is managed and updated in relation to the actions in the physical world. In this case, the game itself does not change, but the virtual layer induces changes in players' strategies. Introducing parameters in the virtual layer allows compensation for disequilibrium between players' real physical abilities and skills. When the virtual elements are overlayed onto the physical worlds, they can help balancing players' differences in technical abilities. For instance, Sano et al. (30) visualized the ball velocity and trajectory to help novice soccer players. They suggested that their system can improve reaction times in passing and receiving the ball for beginners compared to more skilled ones.

Mixed Reality in Physical Education & Sports

Many mixed-reality games obfuscate (intentionally or unintentionally) markers that can be used to infer whether one is playing a game. The experimental location-aware mixed-reality game implemented in our research, The Songs of North (39-40), was designed so that one could play the game only by listening what is happening in the game world using headphones. When the game events required a more active mode of playing, quickly taking out a mobile phone and pushing a few buttons was enough. No exact awareness of the location of other players, for example, was required, and the gaming interface was designed to provide ambient, rather than precise information of the game state to the players. This ambiguity in The Songs of North was intentional and related with other design choices (41).

The key element was to engage "real users" with the design process as early as possible. The reactions of players towards mixed reality gaming were probed in interviews and particularly illustrated scenarios about potential future game implementations were helpful in provoking reactions among our informants. Since no narrative or play scenario is substitute for actual, interactive play experiences in real life contexts, it is important to use care while interpreting the results from such early phases of player studies. In our case, tentative design guidelines were produced that could then be further tested with an actual mixed reality game prototype. These included mixed reality playability guidelines such as (41):

- Ensure that movement will not become too much of a burden to the players,
- Allow different modes of gameplay and support various player types,
- Allow as much free communication between the players as possible,
- Design the interface so that it requires only a minimum amount of handling of the device and pressing of the buttons,
- Integrate some aspects of the game world with the real environment.

The last guideline was particularly important to guide the design of our mixed reality game; there should be interconnections between the fictional game world and the physical, everyday player environment. After analysing our findings, a "three world model" for mixed reality gaming was developed . Players moving between different frames have the flexibility of gaining different information while in different play modes. The player in the left is moving while being logged into his game client, and thereby his avatar (spirit world representation) is able to interact with the entities inhabiting the fictional game world. On the other hand, a player in the right is making a phone call to another player, thereby making use of the game system but on player-to-player level. The "mixed world" of play includes information from both other layers of gaming reality, to the degree these various aspects contribute to the mixed reality gameplay and gaming experience.

2. Conclusion

The application of computer-based technology to sport is an area of intense interest. Such technologies include computerized modelling, data acquisition and analysis,

mobile computers, and information technology networks. For imparting better knowledge, understanding, fun and analysis virtual, augmented and mixed reality plays a key role today.For sports training, corrections of faults, correct judgement and students feedback and spectator satisfaction the application of computer based knowledge is an essential part in the field of sports and physical education.Scientific technology based equipments has develop to make the field of physical education and sports more interesting and effective. By understanding the experience of when individuals are engaged in sport within a VR environment, researchers, coaches, and athletes will able to use the technology for the benefit of athletes and society in general.

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