

A GLIMPSE INTO A POSSIBLE FUTURE OF SPORTS: THE USE OF EXTENDED REALITY

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Abstract

Extended Reality (XR) is gaining popularity in several application areas in recent decades. In this context, this paper aims to analyse how this technology can be applied in the field of sports through the scientific literature published so far.

Introduction

This innovative technology has been adopted in various advanced performance fields such as psychology, medicine and the military. Among the goals are to improve perceptual, cognitive and motor skills.

Motor skills have also been the focus of researchers' attention in relation to other digital technologies, such as LMC (Location and Motion Co-processor)[1] devices or Kinect sensors[2].

The use of extended reality in sport is just beginning. XR technology has developed rapidly to technological maturity but more empirical evidence is needed on how these technologies can be applied in sport to generate progress.



Fig. 1. Milgram Continuum in a sporting perspective. Adapted from Milgram, Utsumi and Kishino.

Material-method/ About XR technology

Extended Reality (XR) falls on a spectrum known as the "reality-virtuality continuum", a concept introduced by Paul Milgram et al[3]. This spectrum covers everything from pure reality to fully virtual reality, including the intermediate stages of augmented and mixed reality. XR explores this continuum, blending the real world with virtual elements and offering a new perspective on human-computer interaction. Extended reality is a collective term used to encompass three types of digital technologies: virtual reality, augmented reality and mixed reality.

Using XR in sport

Recent interests in researching the applicability of Extended Reality (XR) in the field of sport reveal a varied and dynamic territory characterised by the increasing adoption and integration of technologies such as Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). I will initially present a table summarising key information drawn from recent literature:

Table 1. Recent research into the use of XR in sport

Reference	Sport Referred To	Type of Technology Proposed
Mai Geisen et al. (2023)	Golf	Extended Reality (XR) technology used for real-time visual feedback in golf putting training. The study utilizes HoloLens 2 to project a virtual club into the real training environment, providing immediate feedback on the targeted club alignment and velocity, aiming to improve the performance, accuracy, and consistency of golf putts.
Mai Geisen, et al. (2023)	Dance (Extracurricular)	VR-based learning tools in sports education, specifically in extracurricular dance classes, to support didactic, collaborative, and perceptual components.
Jie Zhao et al. (2022)	Various	Extended Reality (XR) technologies, including VR, AR, and MR, used in various aspects of sports such as training, performance, and fan engagement.
Daniela Langaro, et al. (2022)	Soccer	VR technologies to enhance the match day experience for soccer fans, focusing on factors leading to the adoption of VR equipment.
Wei Hong Lo, et al. (2022)	Stadium Sports Spectating	Use of the Flexible XR Prototyping framework for developing AR sports spectating applications, focusing on off-site and on-site prototyping.
S. Palmieri et al. (2021)	Various	Future applications of extended realities (VR, AR, MR) in sports, focusing on enhancing professional and entertainment activities.
Mai Geisen, Stefanie Klatt (2021)	Various	Use of XR technologies to provide visual feedback through displays for real-time corrections in sports training and enhancing performance development.

Wei Hong Lo et al. (2021)	Various	A flexible framework for XR prototyping to address challenges in developing and researching XR prototypes for sports spectating.
A. Miah et al. (2020)	Various	Integration of VR, AR, MR, and XR into sports industries, transforming athletic experiences for participants and audiences with immersive sports experiences.
J. Reneker et al. (2020)	Soccer	Virtual immersive sensorimotor training using VR to improve soccer athletes' performance, functional sensorimotor control, and injury prevention.
S. Palmieri, et al. (2020)	Various	Augmented Reality applications in sports, focusing on creating immersive training experiences and enhancing information delivery and skill improvement.

Zhao et al. present a bibliometric examination of the evolution of applications of Extended Reality technology in sports, covering the period from 2000 to 2021. Their study highlights the most important areas of research interest, including the use of XR systems in sports games, virtual simulation equipment, and the incorporation of artificial intelligence (AI) into athletic training and performance enhancement[4].

In a chapter of a larger work, the focus is on how these immersive environments reconfigure the experience of sport for both participants and spectators, inaugurating new paradigms of experiences that redefine the universe of sport.[5]

The Reneker et al. (2020) study explores the impact of virtual immersive sensorimotor training (VIST) on college football players, focusing on evaluating the effects of this training. The research examines differences in functional sensorimotor control, injury incidence rates, and on-field performance, demonstrating that virtual immersive training can have a significant positive transfer to real-world environments and physical world activities.[6]

In their 2022 research, Langaro et al investigate the adoption of VR equipment in the context of European football, particularly on match day. The study focuses on using an extended technology acceptance model to identify factors influencing the adoption of VR technologies in these circumstances. The results highlight the crucial role of perceived usefulness, enjoyment and positive attitudes in shaping intentions to purchase and use such equipment, providing a new perspective on the VR football experience.[7]

Geisen et al. approach VR as a revolutionary facilitator in sports education, emphasizing its role in enriching extracurricular educational experiences such as dance. Their study focuses on the implementation of a VR rotation task in an extracurricular dance class, with the intention of strengthening the didactic, collaborative, and perceptual aspects of dance instruction. The analysis highlights

the possibilities of integrating VR as an innovative and transformative tool in the context of sports education.[8]

Palmieri leads a groundbreaking study, projecting the future of the sports industry through augmented reality and artificial intelligence technologies. This research aims to develop new methods of education, skill development and entertainment. It envisions a beneficial technological framework and an efficient business model, with aspirations of full implementation by 2030.[9]

Lo et al. develop a framework for Flexible XR Prototyping, highlighting critical steps and factors to consider to optimize the XR prototyping process. The study presents the practical application of this framework, illustrating how it can be used to enhance AR sports performances in a stadium environment.[10]

Geisen explores how Extended Reality (XR) technology can revolutionise sports training by providing instant and immersive feedback. His study compares XR learning environments to traditional methods, arguing that XR creates a more dynamic and effective training environment. His research concludes that the real-time feedback provided by XR can greatly improve golf putting skills.[8]

Conclusions

The implementation of Extended Reality (XR) technologies in sports is becoming increasingly widespread, with studies focusing on sports games, virtual simulation equipment, sports training and rehabilitation programmes. However, some fragmentation is observed in this sector, signalling the need for more integrated and systematic research.[4]

The integration of Extended Reality (XR) technologies with other mainstream technologies is expected to have a positive impact on sports activities in both professional and leisure contexts. The existence of a growing demand for technological innovation to meet the needs of sports users is recognised, thus highlighting the potential to achieve significant benefits at a cost-effective price.[11]

In sports training, Extended Reality (XR) technologies are gaining ground in providing instant feedback during movements. These technologies help refine awareness of one's movement and increase the speed with which athletes assimilate and learn new skills. This real-time support has a beneficial effect on the development and improvement of athletes' performance.[8]

A particular area is the use of XR in Fan Interaction and Spectator Experience. The use of Extended Reality in the world of sport does not stop at honing the skills of athletes, but also extends into the area of enthusiastic fan engagement and enriching the spectator experience. Research is venturing into the use of VR technologies to bring innovation to the way fans experience sporting events, such as game days, and how XR can be integrated to amplify the spectacle and excitement at sporting events. Studies highlight the significance of perceived value, experiential

enjoyment and favorable attitudes as key factors in driving adoption of these emerging technologies.[7]

Future studies could investigate the long-term impact of Extended Reality (XR) based training, assessing its ability to outweigh the benefits of traditional training methods as participants become more comfortable with the technology that will increasingly permeate our lives every day.

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