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A new dimension in learning badminton refereeing: A 3D simulation android app with virtual reality integration

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Abstract*:* Virtual reality (VR) technology has become increasingly popular and widely used in sports environments in higher education, but there are still some challenges that need to be overcome. This research aims to create an Android-based 3D simulation application with the help of virtual reality as a learning tool for badminton refereeing. The methodology used is the Multimedia Development Life Cycle (MDLC). The multimedia development methodology consists of six stages, namely concept, design, material collection, creation, testing, and distribution. This application shows great potential for supporting the development of human resources in the field of badminton sports, both for novice referees and players. However, it should be noted that the current research is still at the application creation stage, with effectiveness and distribution tests still to be conducted. Through the optimisation of rendering techniques, test results show good simulation performance on smartphones with a resolution of 1920 x 1080, although the use of VR Box devices may cause eye fatigue in long-term use. This research makes an important contribution to the development of VR-based learning applications for badminton refereeing, with the hope of improving understanding and skills in sports and becoming the basis for the development of sports education technology. Future research should focus on completing the pending stages as well as expanding insights into user interaction and the positive impact that apps can have.
Keywords: virtual reality, badminton, referee, android

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INTRODUCTION

Recent technological developments have paved the way for revolutionary innovations (Nopembri et al., 2022), among which is virtual reality (VR) technology, which is now growing rapidly and revolutionising various fields (Conole, 2014; Englund et al., 2017). This technology has been widely used in all walks of life and plays an irreplaceable role (Li et al., 2021). VR is a very global term that is often used to describe visual-based computer simulations of real or imaginary environments (Craig, 2014). VR allows users to interact with an environment simulated by a computer, an actual environment that is imitated, or really an environment that only exists in their imagination (Sihite et al., 2013). The goal is to achieve a strong sense of presence in the virtual environment (Putra et al., 2017). As a key technology in modern society, VR technology is increasingly affecting aspects of daily life, including sports education and training (Zhao & Guo, 2022). This virtual education in sports is considered a revolutionary development of educational technology (Li et al., 2021). With VR technology, three-

dimensional images of sports scenes can be stimulated and then displayed on VR devices with the help of computers (Zhang, 2018). The main use of VR technology for sports construction is to collect real sports behaviour data and then complete the corresponding sports experience through feedback (Liu et al., 2017). An interactive sports simulation system based on VR technology allows a teacher to create their own training plan before they enter the actual training environment (Huang et al., 2019).

VR technology is currently widely used at the college or university level (Yu et al., 2021; Zhang & Zhang, 2021a). The adoption of technology in higher education learning is both an innovation and a disruption to conventional learning mechanisms (Dunn & Kennedy, 2019; Tantri et al., 2023). In sports teaching in higher education, VR is used to build a sports simulation training system (Pan, 2015). VR can also be used for assessment, to get feedback on performance, and to train specific skills (Neumann et al., 2018). Furthermore, the wide application of VR technology is beneficial to improving the quality of sports teaching and training by helping students have better knowledge and promoting their physical and mental development (Zhang & Liu, 2016). Although VR technology has become increasingly popular and widely used in sports environments in higher education, there are still some challenges that need to be overcome (Zhang, 2018). For example, there are still many universities that have not implemented VR technology in teaching (Zhang, 2018). This is because the availability and relatively high cost of VR devices can be a barrier for educational institutions that have limited budgets (Chiang, 2021). In addition, the integration of VR with teaching methods and the involvement of sports teachers also need to be considered to maximise its benefits (Lee & Shvetsova, 2019). By understanding and addressing these challenges, the use of VR in sports teaching in higher education can reach its full potential and have a significant positive impact on students.

Based on several previous studies, it has been proven that VR technology has been widely used for sports learning in higher education. Such as physical training learning innovation (Yang, 2018), application of VR technology in swimming teaching (Guo, 2016), application of VR technology in cliff length learning (Liu et al., 2022), application of VR for athletic education (Wang et al., 2017), application of VR for basketball teaching tactics training (Huang et al., 2019; Pagé et al., 2019), application of VR technology for table tennis learning (Michalski et al., 2019; Zhang & Zhang, 2021b), application of VR technology for football learning (Zhao & Guo, 2022). However, despite these studies, there are no other researchers who discuss the use of VR technology in badminton learning, especially in badminton refereeing material. This indicates a gap and the urgency of conducting further research in this area. By conducting this research, we can explore the potential of VR technology in improving students' learning and understanding of badminton refereeing. Therefore, there is a gap and an urgent need to conduct research that creates VR-based learning applications specifically for badminton refereeing. This research aims to create an Android-based 3D simulation application with the help of virtual reality as a learning tool for badminton refereeing. With this application, it is expected that students can gain a more in-depth interactive experience and improve their skills in understanding the rules, judgements, and refereeing decisions related to badminton. Previous research studies also support the view that innovative technology can facilitate learning creativity and productivity (Daharis et al., 2023; Perdima et al., 2022), so this research can be the first step in developing more modern and effective learning strategies in the future.

METHODS

This research method uses the Multimedia Development Life Cycle (MDLC) sourced from Luther (Putra et al., 2017). The multimedia development methodology consists of six stages, namely concept, design, material collection, creation, testing, and distribution. These six stages do not have to be sequential in practice; they can be interchanged. However, the concept stage should be the first thing to be done (Putra et al., 2017).

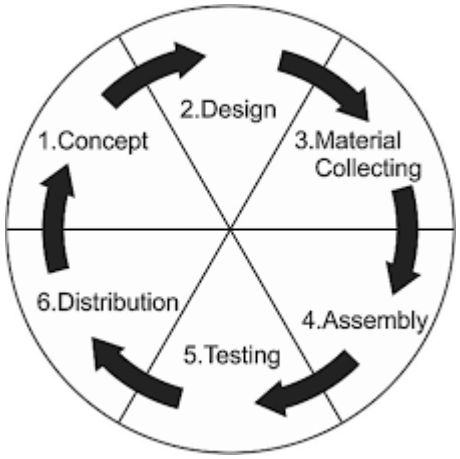

Figure 1. The Stages of MDLC

Stages of MDLC method include:

Concept

In the concept stage (conceptualization), the fundamentals of the to-be-created and developed multimedia project are formulated (Fenu & Pittarello, 2018). Especially on the purpose and type of project to be created.

Material Collecting

Material Collecting is the phase in which materials that correspond to the tasks at hand are gathered. In relation to the content that is to be submitted, multimedia files comprising audio, video, and images are required to be incorporated into the multimedia project's presentation.

Assembly

During the assembly phase, every object or multimedia file is created. The obtained materials and multimedia files were subsequently arranged and assembled in accordance with the design (Lima et al., 2017). In this procedure, expert knowledge is required to achieve favourable results.

Testing

The testing phase (testing) is initiated subsequent to the assembly stage through trial-and-error execution. By incorporating the outcomes of the multimedia initiative into the education of minors, trials are carried out. It is intended that prior work be completed just prior to its implementation in mass learning.

Distribution

Results dissemination and phase multiplication for users. It is essential that multimedia be appropriately bundled in accordance with the method of media distribution, be it CD, DVD, download, or another format.

RESULT AND DISCUSSION

This research is currently in the development stage to create a 3D simulation Android application with virtual reality (VR) integration as a learning aid for badminton refereeing. Although the app is still in the development stage, this section outlines the progress that has been made so far. The development team is committed to ensuring that the app not only offers an engaging learning experience but is also accurate and informative for gaining a deep understanding of badminton refereeing. By utilising 3D simulation technology and VR integration, it is hoped that the app can provide an immersive learning experience, allowing users to experience the atmosphere of a live match in a safe and controlled setting.

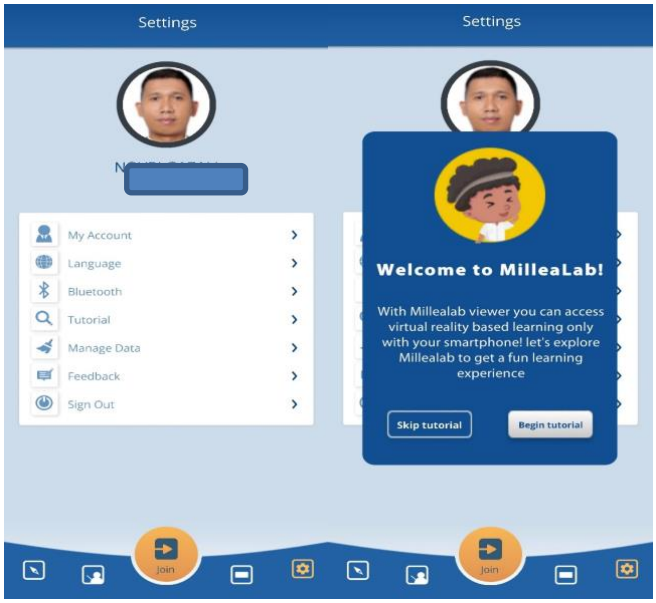

Figure 2. Setting

Figure 2 depicts the process of logging in with a Gmail.com account. After logging in, users are granted effortless access to a multitude of supplementary functionalities. Users are able to configure and modify their account information, such as their name, email address, and additional preferences, through the "*My Account*" function. Users have the ability to choose the preferred language for the user interface through the "*Language*" menu. Additionally, users can attach their Bluetooth devices through the "Bluetooth" menu, which enables the use of any necessary accessories or supplementary devices. The application's "*Tutorial*" interface offers a comprehensive, sequential instruction manual to assist users who are inexperienced with utilising the app's functionalities. Furthermore, through the "*Manage Data*" menu, users are able to store and organise their training outcomes as well as their progress towards comprehending the fundamental principles and rules of badminton. By means of the "*Feedback*" function, users are able to provide evaluations and recommendations that aid the developers in perfecting and enhancing the user experience as a whole. Lastly, the "*Sign Out*" menu provides users with the ability to log out of their accounts, thereby enhancing protection against unauthorised access.

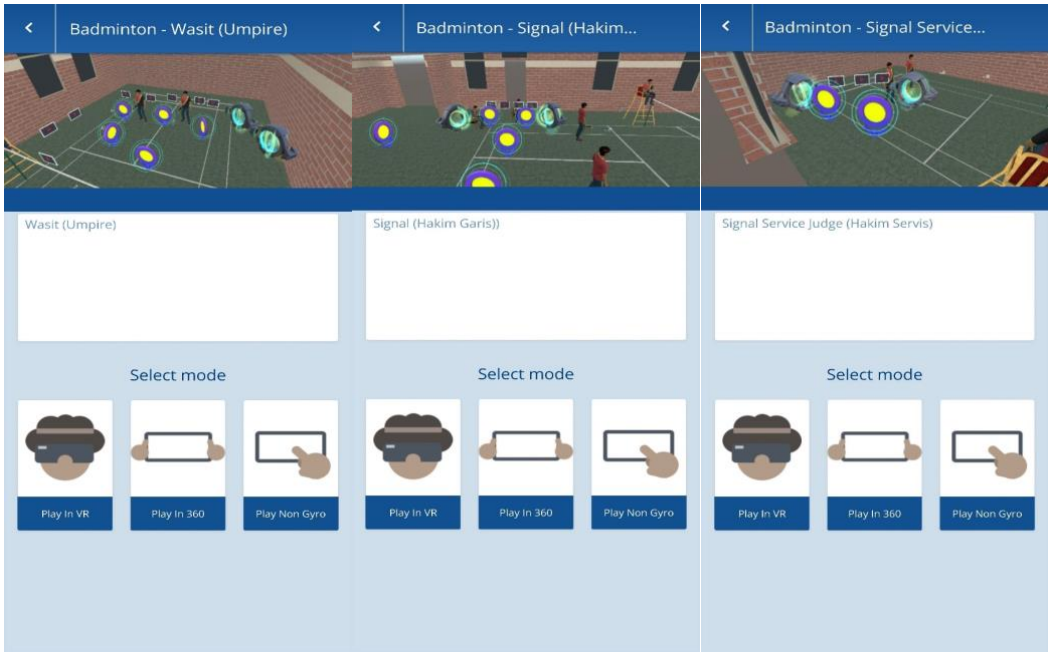

Figure 3. Select Mode

In Figure 3, there is a VR display of the badminton referee (referee), signal (line judge), and service signal. There are 3 modes of choice: play in VR, play in 360, and play non-gyro. This VR display offers users an immersive experience, allowing them to step into the shoes of a badminton referee, observe signals from line judges, and understand service signals with enhanced clarity. The 'play in VR' mode enables users to engage fully with the virtual environment, providing a realistic simulation of being on the court. Alternatively, the 'play in 360' mode offers a panoramic view, allowing users to observe the entire court from various angles. For those without gyroscopic capability on their devices, the 'play non-gyro' mode ensures accessibility, offering an alternative method of interaction within the application.

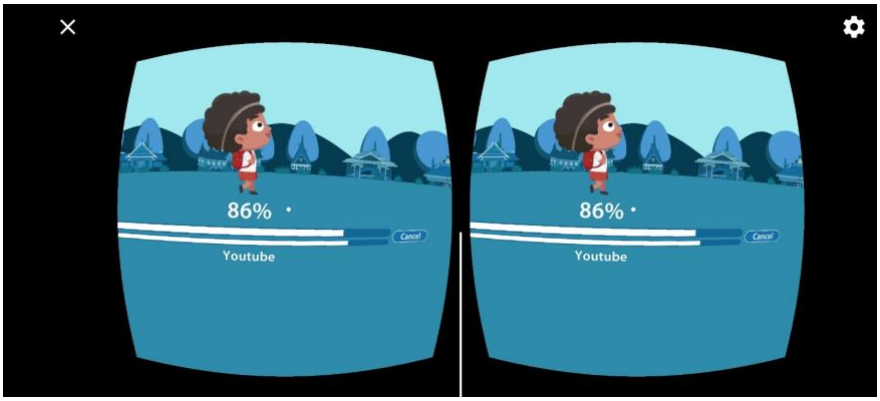

Figure 4. Loading VR

Figure 4 shows the VR loading process that reaches 100%. This display will go through the process of loading assets and links that have been added previously, such as YouTube links and others. There are 3 mode options: play in VR, play in 360, and play non-gyro. After reaching 100%, users will be directly directed to an interactive virtual environment according to the selected mode option. This loading process ensures that the user's experience of exploring the virtual environment occurs without any distracting hitches or pauses. Users can also experience optimal loading speed thanks to an optimised asset loading process to ensure maximum responsiveness and quality in application usage.

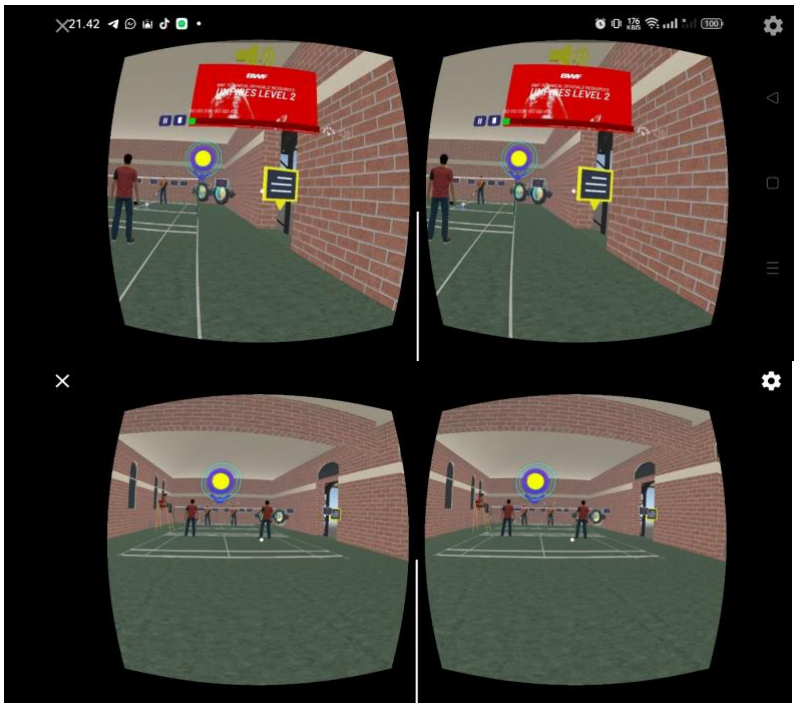

Figure 5. VR with Stand Point

In Figure 5, the VR view contains a centre point that can be accessed to go to the standing point to move and bring up the narration and YouTube video link as audiovisual media. This feature allows users to get further explanations about the rules and strategies of badminton games directly from a reliable source. Users can easily access the required information by directing their gaze to the centre point of the virtual environment, thus enhancing the hands-on and interactive learning experience. YouTube video links also enrich the user experience by providing visual demonstrations of techniques and tactics in the game, helping them to better understand complex concepts and increasing their engagement in learning.

This research focuses on developing an Android-based 3D simulation application with virtual reality (VR) integration as a learning tool for badminton refereeing. Although this application is still in the development stage, a number of significant progresses have been made in making it. The Android-based 3D simulation application with virtual reality (VR) integration developed in this research offers a number of important advantages in badminton refereeing education and training. Previous research has shown that the use of VR technology in an educational context provides a more immersive and interactive learning experience (Di Natale et al., 2020; Liu et al., 2020). The integration of VR allows users to experience a badminton match situation firsthand, which can enhance their understanding of the duties of referees and linesmen.

This application is also relevant to technological developments in sports, as has been discussed in research on VR applications in sports (Ochi et al., 2016; Zhang, 2018). Another impact on football refereeing has been investigated by Akiyama et al. (2020) and Van-Biemen et al. (2023), who highlighted the effectiveness of VR as a representative training environment for football referees. Kittel et al. (2019) also noted that VR applications are appropriate assessment tools for the assessment of off-field decision-making by football referees. By referring to these studies, we can expand our understanding of the potential of Android-based 3D simulation applications with VR integration in the context of badminton refereeing. The use of these applications can also help accelerate the learning curve for beginners in the role of refereeing, which in turn can improve the overall quality of refereeing in the sport of badminton.

Furthermore, this research has great potential to support human resource development in badminton. The app can be used as an effective training tool for novice referees and line judges, enabling them to understand the rules of the game better. In addition, badminton players can also use this app to deepen their knowledge of the rules and refereeing process, which can improve their integrity and understanding of the game. This is in line with efforts to promote education in sport, where technology can play an important role in improving the understanding and skills of athletes and match officials (Liu et al., 2020; Venugopal, 2023). In research by Billaut et al. (2012) and Mascret et al. (2022), VR technology has been shown to improve athletes' performance in training and competition. Thus, the use of an Android-based 3D simulation application with VR integration not only opens up accessibility to better information and training but also enriches the learning experience for badminton practitioners and fans as a whole.

This discussion can underline the importance of developing this application to overcome barriers that may be faced in badminton refereeing (Subarkah et al., 2020). For example, these apps can help overcome the limited access to live training or live matches for referees and linesmen by providing a more accessible and flexible learning experience. This will be particularly important in the context of the COVID-19 pandemic, where social and travel restrictions may hinder opportunities for live training (Nijjar et al., 2023; Zieschang et al., 2023). By highlighting the contribution of these apps in overcoming such barriers, we can emphasise the importance of continuously developing technological solutions in sports education and training. In addition, Android-based 3D simulation apps with VR integration can also serve as effective instruments to facilitate remote training for referees and linesmen. With this technology, they can stay connected and trained virtually without having to be face-to-face, reducing the risk of transmission during the pandemic and providing flexibility in the development of refereeing skills.

The results of this study make a new contribution to the development of sports education technology. In previous research, VR integration has been investigated in various contexts (Faure et al., 2020; Neumann et al., 2018; Nor et al., 2020), but specific applications for badminton umpiring education are still limited. The findings of this study contribute to the literature by introducing a cutting-edge learning tool that referees, linesmen, and badminton players can use to better comprehend

refereeing tasks and rules in game situations. The results of this study have paved the way for a deeper understanding of the potential of VR technology in immersive education and training. With the integration of VR, users can directly experience badminton games, which enables the development of better refereeing skills. In addition, the application allows badminton players to become more familiar with the rules of the game and the umpiring process, which in turn can enhance their badminton playing experience and integrity in matches.

The research also illustrates the importance of cross-disciplinary collaboration between technology and sport to drive new innovations. As virtual reality (VR) and similar technologies continue to permeate the realm of sports, our comprehension of the ways in which applications can aid in the development of athletes and match officials grows. This type of collaboration not only contributes to the advancement of technology but also yields tangible advantages for the sports industry through the introduction of novel approaches to training and human resource development challenges. Prior investigations have demonstrated the potential of virtual reality (VR) applications for competitive athletes (Lee & Kim, 2018), and Akbaş et al. (2019) emphasised the advantages of incorporating VR into athletic training in terms of health and body composition. Furthermore, our research application significantly contributes to this field by providing a heightened level of immersion and interactivity, which facilitates the comprehension of intricate refereeing tasks. Therefore, our results unequivocally substantiate the efficacy of virtual reality (VR) technology implementations in delivering inventive approaches to athletics training and human resource development.

In addition, this research provides an opportunity for deeper reflection when the potential for technology to influence the future of sport is discussed. Through the applications depicted in this study, we can reflect on how technology may influence the development of athletic rules and procedures. This discourse may stimulate new ideas regarding potential modifications to game rules that would benefit from existing technological developments (Veale, 2020). Furthermore, this research can serve as a foundation for further exploration of the integration of technology in the overall development of sport, which can open the door for broader innovation and more progressive thinking in the field of sport (Bădescu et al., 2022; Dergaa & Chamari, 2024). Therefore, this research covers not only the development of applications but also the relationship between technology and the evolution of sport in general, which could result in substantial changes to the way we perceive and engage in sport. This suggests that the influence of technology on sport is not limited to device innovation but also extends to other aspects of sport culture and regulation.

The limitations of this research need to be noted. Although the Android-based 3D simulation app with Virtual Reality (VR) integration promises various advantages, this research only reached the app creation stage, and the effectiveness testing and distribution stages have not been realised. To ensure the success of this app, future research should expand its scope to include these critical stages. Further evaluation of stakeholders and end-users will be required to gauge the impact and acceptance of this app in practice. Nonetheless, it is important to remember that app development is not finished with the creation stage alone. There needs to be a next step in the form of effectiveness and distribution testing to ensure that the app can actually deliver the expected benefits. In addition, future research should also pay attention to further aspects of user interaction as well as the potential positive impact that this application can have in supporting badminton refereeing education and training. With the commitment to complete these important stages, it is hoped that this application can provide greater and more significant benefits to the development of badminton refereeing as a whole.

CONCLUSSION

Based on the test results on a three-dimensional virtual reality (VR) simulation application, by optimising the rendering techniques of the elements in the application, the simulation performance can run well on a smartphone with a resolution of 1920 x 1080. The application, consisting of four simulation scenarios, can be exported and installed without a hitch. However, we note that using a smartphone with the VR Box device can still cause eye fatigue, which needs to be taken into consideration for long-term use. The main contribution of this research is the development of an Android-based 3D simulation application with virtual reality (VR) integration that can significantly support education and training in badminton refereeing. This application provides an innovative solution to deepen the understanding and experience of the game and refereeing, both for athletes, referees, and linesmen. Through this research,

we hope to assist in improving the quality of understanding and skills in the sport of badminton, as well as provide a basis for further development of educational technology in the context of sport. With all these efforts, we are optimistic that the results of this study have the potential to positively influence sports education and be a valuable contribution to the world of badminton refereeing.

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