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Real-Time Walking Platform for Navigation in Virtual Reality

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Abstract
This paper examines the proliferation of virtual reality (VR) technology and the evolution of interaction tools. Specifically evaluating the contribution of enhanced walking platforms to the VR experience. VR technologies have rapidly proliferated, offering a wide range of applications from education to health, industrial simulations to entertainment. This evolution has led to the emergence of sophisticated interaction tools. After a detailed review of the tools used for VR interaction, the paper focuses specifically on enhanced walking platforms that offer users a real-world walking experience. These platforms are characterized by precise motion detection sensors, haptic feedback systems, and natural gait simulation. Studies show that these platforms allow users to have a more realistic experience and enhance their interaction with the virtual world. In this study, a Walk-in-Place platform was designed and developed to enhance the users' VR experience and interaction. The method employed to enhance the Walk-in-Place platform involved initially identifying user needs, followed by crafting a concept design tailored to these needs, and subsequently encompassing prototype development and iteration processes. The developed prototype was validated through user testing and performance assessments, thereby ensuring the platform's user-friendly interface and accurate walking detection capability. The effectiveness of this specially designed product was demonstrated by using it in 3 different application areas.

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1. Introduction

The rapid advancement of technology in recent years has brought a series of new experiences and forms of interaction into our lives. Virtual Reality (VR), one of the pioneers of these developments, stands out as a technology that takes people to a completely different dimension and pushes the boundaries. VR is a system that takes the user out of the real world, transports them to a digital environment and provides interaction in this environment (Siricharoen, 2019). This allows the user to completely forget about environmental factors and fully focus on the virtual world. Increasing the interaction of users in the virtual world will increase the sense of reality to a higher level. Many different equipment and software have been developed for this purpose. The most important of these are 3D Graphics and Sound (Zhou et al., 2004). To provide a realistic experience, VR uses impressive 3D graphics and sound effects (Fırat et al., 2022). This gives the user the feeling of a real world around them. In addition, Motion

Detection and Tracking devices have been developed to enable interaction between the user and the virtual World (Boas, 2013).

These devices detect and track the user's movements. This allows the user to interact and move around the virtual world in a real way. Another important group of equipment is Sensory Feedback devices (Richardson et al., 2006). These devices provide feedback to the user's touch, pressure and other senses. Haptic technologies are used for this purpose (Biswas and Visell, 2021). This enhances the feeling of touching or interacting with objects in the virtual world (Gallace and Girondini, 2022).

In this work, Amidst the swift proliferation, the contribution of advanced Walk-in-Place Platforms to the VR experience cannot be overlooked. Next-generation Walk-in-Place Platform enable users to move freely in the virtual realm, enriching the interactive experience and transcending boundaries. This article explores these remarkable developments in the proliferation of virtual reality, with a specific focus on the contributions of advanced Walk-in-Place Platform to the evolution of interactive tools. The aim of this study is to develop a product that can be included in the group of motion detection and tracking technologies. With the device to be designed and developed, users will be able to move in the virtual world with real walking and running movements.

2. Literature Review

VR technologies are used in many different fields and applications. The most common areas of use are Education and Simulation (Kavanagh et al., 2017), Entertainment and Games (Carvalho et al., 2016), Health and Rehabilitation (Kiper et al., 2010), Engineering and Design (Berni and Borgianni, 2020), Tourism and Cultural Experiences (Marasco, 2020), Mental Health and Therapy (Emmelkamp and Meyerbröker, 2021). Many studies have been conducted and products have been launched in all these areas. The platform developed in this study has been applied and tested in the fields of education and simulation, entertainment and gaming, and Engineering and Design.

Walk-in-Place Platform designs similar to the one in this study have been developed and used. These platforms are generally categorized into four different categories. These are; Omni Walking Platforms, Arch and Rotating Platforms, Hydraulic Platforms and Wheeled Walking Platforms.

In Omni Walking Platforms, the walking motion is sensed by a central unit of the platform and this information is transmitted to the virtual world (Hooks et al., 2020). The user feels the walking motion, but physically remains at the same point. Some models use a belt system, while others detect movement with sensors that track foot movements (Wilson et al., 2023).

In Belt and Swivel Platforms, the user stands on a rotating platform connected to an attached belt. The belt detects the user's walking motion and allows them to move in the virtual world.

Hydraulic Platforms, the user's walking motion is detected by standing on a hydraulic platform (Vasylevska et al., 2015). The hydraulic system simulates the user's tilt and rotation movements.

With Wheeled Walking Platforms, the user stands on a wheeled platform and can simulate the walking motion (Vasylevska et al., 2015). The platform tracks the user's movement and allows them to move in the same direction in the virtual world.

These platforms make the VR experience more interactive, allowing users to feel more freedom in the virtual world (Olivier et al., 2017). Each platform has advantages and disadvantages and the choice can vary depending on user needs and experience goals (Hamad and Jia, 2022).

In this study, a platform has been developed for VR users that can navigate in the virtual world by walking in place in the real world. The developed system does not change the physical location of the user while walking in the real world. An infinite movement area is created for the user. In this way, the user's position in the virtual world changes according to the movement made in the real world.

3. Materials and Methods

A hardware that will allow users moving in the real world to move synchronously with their characters in the virtual world has been developed. In the developed application, the user performs the actions of walking, looking left-right, and looking right-left on this platform in order to complete the VR phenomenon. In other words, the movements in the application are practiced by the user through this platform.

A suitable platform was designed for users to move in the real world in two dimensions. The 3D design of the designed platform is shown in Fig. 1. As can be seen, the platform basically consists of two structural parts. The upper module is the region where the walking movement is performed. The lower part allows the upper part to rotate 360 degrees.

After this modeling study, iron profile material was used in the product produced by computer-aided CNC machine. The produced platform weighs 180 kg, has a diameter of 100 cm and a height of 150 cm. With this shape, it is quite robust and ergonomic.

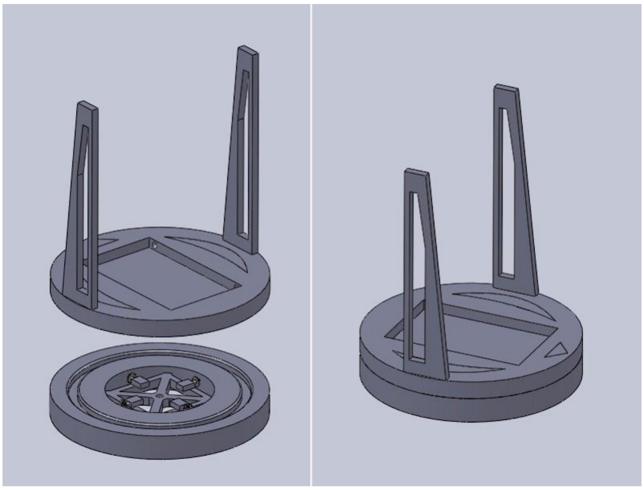

Figure 1. 3D model of designed Walk-in-Place platform

The side arms were used to fix the protective circle prepared to prevent the user from falling on the platform. As can be seen in Fig. 2, the environment where the user is located is limited and the user is prevented from falling. On the sides of the platform, compartments were made to put the computers where the applications will run and the virtual reality glasses will be installed.

In Fig. 3, buttons are placed on the platform that the user can easily access and change the platform features. These are; Red for walking speed, White for right-left rotation speed and Green for compass sensor sensitivity. A compass sensor that communicates with the microcontroller via the USB port in the joystick box was also used. This compass sensor should be placed directly at the (0,0) point of the user's head.

In Fig. 4, the Arduino-based control card was designed for the control of the developed hardware. With the developed card, the motors in the system are controlled and the status information is transferred to the software that controls the avatar in the virtual world. Oculus Rift DK2 virtual reality glasses are used as the VR platform. Since Oculus Rift DK2 does not have its own battery, it makes a direct connection to the hardware on which the virtual system works.

Figure 2. Assembled Walk-in-Place Platform

Figure 3. Control System for Walk-in-Place platform

4. Findings and Discussion

The developed platform can be used in all applications that require avatar mobility in VR technology areas. And it significantly increases user interaction. Applications in the fields of tourism, entertainment and gaming, and Engineering and Design were selected to test the developed platform. The working performance of the system was determined by testing with sample applications.

The first application was chosen to visit touristic ruins, which is an important usage area of VR technologies. Göbeklitepe in Şanlıurfa, a city in Turkey, was chosen for this application. First of all, the past state of the region was modeled in three dimensions with the Blender application in line with the information received from experts. The necessary rendering process was done with Oculus Rift DK2 to watch the obtained model in VR environment. Necessary operations were performed to control the movement of the avatar with the platform. In this way, as seen in Fig. 5, the designed area has become navigable and visible with the Walk-in-Place platform.

In the second application area, the studies in the field of Engineering and Design were selected. With this application, it was possible to navigate an unbuilt structure. As shown in Fig. 6, the user is given the feeling of walking around the real house with the platform developed. Such

Figure 4. Working Walk-in-Place Platform

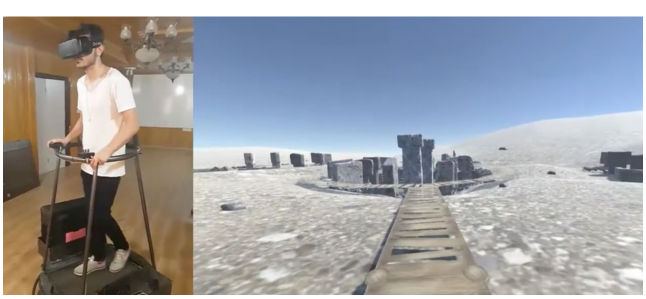

Figure 5. Touristic Area Tour Application (Göbeklitepe)

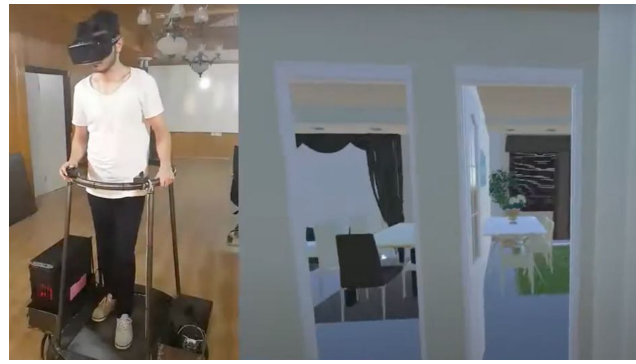

Figure 6. House Tour with Design Project

an application increases the marketing opportunity for the builder of the house without actually completing the house.

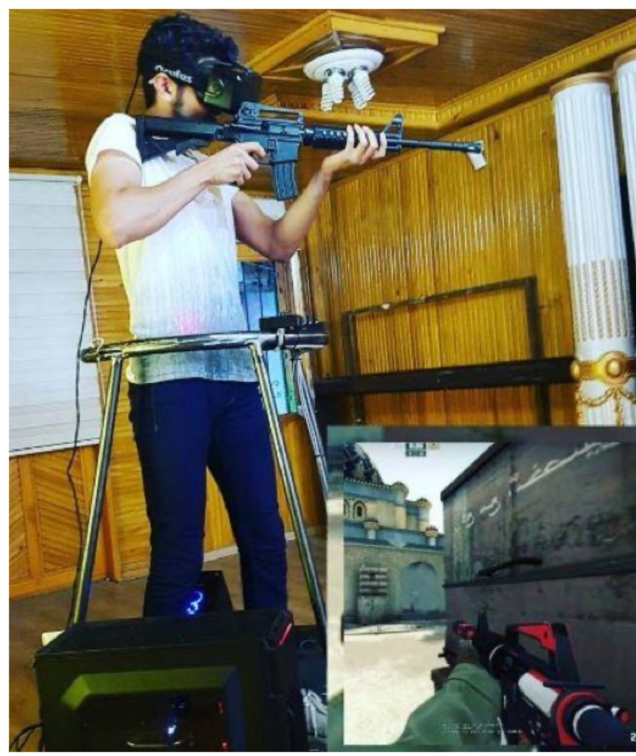

Figure 7. Use of The Walk-in-Place Platform in First Person Shooter (FPS) Games

Finally, entertainment and game area were selected from the VR applications. In the application shown in Fig. 7, the platform developed for the movement of the user's avatar in the FPS game was used. The VR versions of existing games in the market were applied. The platform user navigates in the game environment by walking in the developed environment. In addition, a weapon that can be utilized for FPS games was designed and developed. This weapon is designed to make the shooting function of the user in the game feel like a real weapon.

The developed Walk-in-Place platform, incorporating original design, aims to provide users with an unparalleled walking experience. Specifically designed to enable users to interactively navigate different virtual environments through real-world walking, this platform represents a distinct approach. In addition, designed to grant users the ability to interactively move in various virtual environments through real-world walking, this platform is crafted with a special purpose. The unique structure of the platform allows users to navigate virtual spaces naturally while precisely sensing walking movements. The unique structure of the platform allows users to traverse virtual spaces naturally while accurately detecting walking movements. This endeavor aims to introduce a new era in virtual reality by offering users an immersive experience unlike anything they have experienced before. In the discussion section, we will focus on the unique features and potential of the developed Walk-in-Place platform, thoroughly evaluating the innovations it brings to the virtual reality experience. Additionally, we will provide strategic insights into the impact this platform could have on users and its potential contributions to future virtual reality technologies.

5. Conclusion

In this paper, we explore a Walk-in-Place Platform designed to further enrich the virtual reality (VR) experience, allowing users to experience the sensation of walking in the real world. Our enhanced platform aims to provide users with an exceptional experience by uniquely combining the interaction between the virtual and real world.

First of all, we focused on the technical details of this enhanced platform, which includes a mechanism that simulates the user's natural walking motion. In this way, it allows the user to move completely freely in the virtual world, making the VR experience more immersive.

User experience tests show that the enhanced Walk-in-Place platform accurately simulates the feeling of walking in the real world and allows users to feel a deeper connection in the virtual world. Participants realized that they have the freedom to interact with their surroundings while navigating the platform and how this experience enhances real-world interaction.

This enhanced Walk-in-Place platform has various potentials in a range of application areas, from education and entertainment to healthcare applications and industrial simulations. Future research should focus on further developing the platform and examining use cases in different sectors. The developed platform takes the virtual reality experience to a new level, allowing users to interact more closely with the real world. This could be an important milestone in the future evolution of virtual reality technology.

6. Acknowledgement

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References

Berni, A. and Borgianni, Y. (2020). Applications of virtual reality in engineering and product design: Why, what, how, when and where. *Electronics*, 9:1064.

Biswas, S. and Visell, Y. (2021). Haptic perception, mechanics, and material technologies for virtual reality. *Advanced Functional Materials*, 31:2008186.

Boas, Y. (2013). Overview of virtual reality technologies. In *Interactive Multimedia Conference*, volume 2013. sn.

Carvalho, B., Soares, M., Neves, A., Soares, G., and Lins, A. (2016). Virtual reality devices applied to digital games. a literature review. *Ergonomics in Design: Methods and Techniques*, pages 125–136.

Emmelkamp, P. M. and Meyerbröker, K. (2021). Virtual reality therapy in mental health. *Annual review of clinical psychology*, 17:495–519.

Fırat, H. B., Maffei, L., and Masullo, M. (2022). 3d sound spatialization with game engines: the virtual acoustics performance of a game engine and a middleware for interactive audio design. *Virtual Reality*, pages 1–20.

Gallace, A. and Girondini, M. (2022). Social touch in virtual reality. *Current Opinion in Behavioral Sciences*, 43:249–254.

Hamad, A. and Jia, B. (2022). How virtual reality technology has changed our lives: an overview of the current and potential applications and limitations. *International journal of environmental research and public health*, 19(18):11278.

Hooks, K., Ferguson, W., Morillo, P., and Cruz-Neira, C. (2020). Evaluating the user experience of omnidirectional vr walking simulators. *Entertainment Computing*, 34:100352.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., and Plimmer, B. (2017). A systematic review of virtual reality in education. *Themes in Science and Technology Education*, 10(2):85–119.

Kiper, P., Turolla, A., Piron, L., Agostini, M., Baba, A., Rossi, S., and Tonin, P. (2010). Virtual reality for stroke rehabilitation: assessment, training and the effect of virtual therapy. *Medical Rehabilitation*, 14:23–32.

Marasco, A. (2020). Beyond virtual cultural tourism: History-living experiences with cinematic virtual reality. *Tourism and Heritage Journal*, 2:1–16.

Olivier, A.-H., Bruneau, J., Kulpa, R., and Pettré, J. (2017). Walking with virtual people: Evaluation of locomotion interfaces in dynamic environments. *IEEE transactions on visualization and computer graphics*, 24(7):2251–2263.

Richardson, B., Symmons, M., and Wuillemin, D. (2006). The contribution of virtual reality to research on sensory feedback in remote control. *Virtual Reality*, 9:234–242.

Siricharoen, W. (2019). The effect of virtual reality as a form of escapism. In *CONF-IRM 2019 Proceedings*.

Vasylevska, K., Podkosova, I., and Kaufmann, H. (2015). Walking in virtual reality: flexible spaces and other techniques. *The Visual Language of Technique: Volume 2-Heritage and Expectations in Research*, pages 81–97.

Wilson, E. B., Canete, S., Wright, W. G., and Jacobs, D. A. (2023). Influence of visual augmented feedback on walking speed perception in immersive virtual reality. *PRESENCE: Virtual and Augmented Reality*, pages 1–12.

Zhou, Z., Cheok, A. D., Yang, X., and Qiu, Y. (2004). An experimental study on the role of 3d sound in augmented reality environment. *Interacting with Computers*, 16(6):1043–1068.