2025 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)

2025 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) | 979-8-3315-1484-6/25/$31.00 ©2025 IEEE | DOI: 10.1109/VRW66409.2025.00347

Low-cost DIY 16 Directions of Movement Walk-in-Place Interface for VR Applications

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Abstract

Traditional virtual reality (VR) locomotion systems often rely on costly treadmills or sophisticated motion capture technologies, limiting accessibility for broader audiences. This study introduces a highly affordable do-it-yourself walk-in-place interface for VR applications. The proposed interface is built using widely available materials, such as cardboard and aluminum foil, integrated with touch sensors and Bluetooth communication. The interface supports 16 directions of movement and can be constructed for approximately $50. This study demonstrates the potential of budget-friendly solutions to enhance VR. The proposed approach broadens access to immersive VR experiences and bridges the gap between functionality and affordability of VR systems.

Index Terms: Locomotion, walk-in-place, low-cost VR.

1 Introduction

Locomotion is a fundamental aspect of virtual reality (VR) applications and significantly affects user immersion and interaction. Among the various locomotion methods, physically walking or simulating walking movements offers the most natural and immersive experience. However, the high costs of traditional treadmill-based solutions for walking in VR environments limit their accessibility for broader use.

Walk-in-place (WIP) systems are attracting increasing attention as cost-effective alternatives [2]. These systems enable users to simulate walking movements from a stationary position, offering a practical and affordable approach to VR locomotion. Existing WIP systems often utilize camera-based tracking, Kinect sensors, or motion-capture technologies. However, achieving high precision requires multiple cameras or Kinect devices [1], which significantly increases the complexity and cost. Likewise, although motion-capture-based WIP systems can track accurately, their high costs hinder widespread adoption [4]. Attempts to develop low-cost motion capture solutions have resulted in systems priced at approximately $500 [5], which can still be considered expensive for many users. Similarly, while inertial measurement unit-based systems offer effective tracking with reduced error rates, they still rely on specialized hardware and calibration [3].

To address these challenges, we propose a do-it-yourself (DIY), a highly affordable WIP interface capable of supporting 16 directions of movement. Our proposed interface can be constructed for approximately $50, making it a highly accessible cost-effective solution that does not compromise its functionality. The proposed design aims to inspire VR enthusiasts and motivate researchers by introducing a practical and budget-friendly locomotion method for VR applications.

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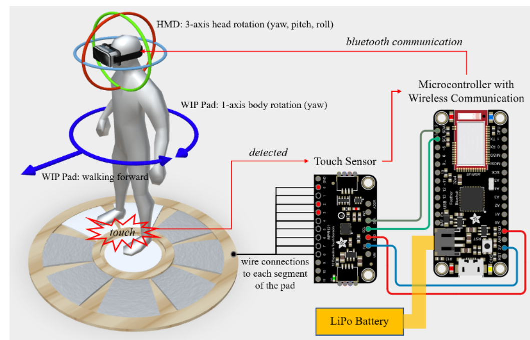

Figure 1: Concept of the proposed WIP interface for VR navigation using foot movement and body direction.

2 Development Process

The development process of the proposed DIY WIP interface aimed to provide a cost-effective and intuitive solution for VR locomotion. The development is structured into two key stages: WIP pad construction and connecting the pad to the system. Figure 1 illustrates the concept of the interface, in which a user wearing a HMD stands on the WIP pad and simulates walking in place to navigate the virtual environment. The user can shift the position of their right foot naturally across different segments of the WIP pad by changing the direction of their body. This interaction enables the system to determine the direction of the user in the VR space. Touch sensors and Bluetooth communication are integral components in this process.

2.1 WIP Pad Construction

The WIP pad is designed as a circular board made of lightweight and affordable cardboard. The inner circle serves as a stable area for the user's left foot, while the outer ring is divided into eight equal segments. These segments correspond to possible positions of the right foot. The design ensures that when the user changes their body orientation, their right foot naturally shifts to a different segment or simultaneously straddles two segments. This layout enables the system to detect subtle changes in the foot position and body direction. Figure 2 illustrates the design of the WIP pad, depicting a scenario in which the right foot simultaneously steps on the N and NE segments. This configuration indicates that the user's body is rotated counterclockwise by approximately 90°and aligned between the W and NW directions.

2.2 Connecting the WIP Pad to the System

To enable interaction with the VR applications, the WIP pad was integrated into a microcontroller-based system utilizing an Arduino ecosystem. Each segment of the pad, including the central area and the eight directional segments, is equipped with touch sensors. These sensors detected foot placement and transmitted it to the microcontroller.

The microcontroller processes the touch inputs and determines the activated segment(s). The data are then transmitted wirelessly

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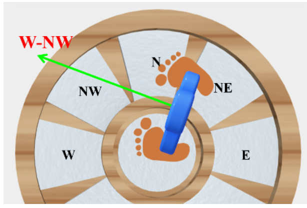


Figure 2: WIP pad design showing right foot on N and NE segments, indicating a body rotation between the W and NW directions.

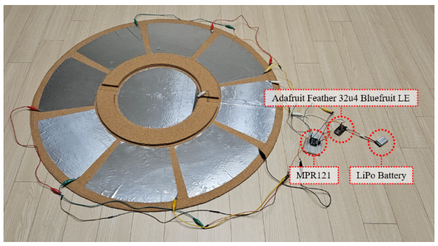


Figure 3: Complete implementation of the WIP interface, showing the constructed pad and connected electronics.

to the HMD using the Bluetooth module. The transmitted signals are mapped to the corresponding movement or direction commands in the VR application, enabling users to simulate locomotion and body orientation changes naturally and in real-time.

The utilization of generalized hardware and software designs ensures the system design remains adaptable and emphasizes the seamless integration of hardware and software to realize an intuitive and affordable WIP interface.

3 Implementation

The design principle illustrated in Figure 2 was adopted to construct a functional WIP pad using a circular cardboard platform. Aluminum foil was attached to the central area and eight directional segments to serve as conductive touch surfaces. These conductive surfaces were connected to touch sensors to enable the detection of foot placement and movement.

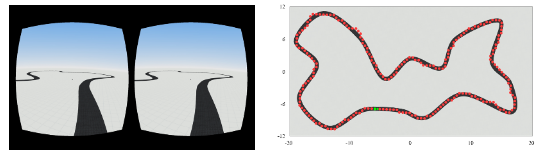
The system uses Bluetooth Low Energy (BLE) and Human Interface Device (HID) functionalities to transmit detected touch inputs to the VR application. An Adafruit Feather 32u4 Bluefruit LE board equipped with BLE capabilities was used as the microcontroller. For touch sensing, an Adafruit MPR121 touch sensor, which supports HID functionality, was integrated into the board. The MPR121 detects foot contact with aluminum foil segments and transmits the information to the microcontroller. The system consumes low power, and a lithium-polymer battery was used as the power source to ensure portability.

Figure 3 illustrates the complete implementation of the WIP interface, including the constructed pad and connected electronics. The DIY interface was constructed at an affordable cost of approximately $50, making it an accessible solution for VR enthusiasts and researchers.

4 Demonstration

A demonstration scenario, in which the user navigates along a predefined path in a virtual environment, was devised to evaluate the functionality of the proposed WIP interface. A smartphone-based HMD was used during the demonstration to ensure the affordability of the system.

Figure 4(a) shows the stereoscopic rendering displayed on the HMD during the demonstration. The user interacts with the virtual environment by simulating walking in place and changing the body orientation on the WIP interface. Figure 4(b) presents the layout of the predefined path, approximately 40m × 24m, along with the trajectory of the user after completing a full lap around the path. While occasional deviations from the path were observed, the user successfully executed most directional changes, demonstrating the effectiveness of the system in enabling natural navigation. The demonstration video[1] further illustrates the performance of the system and its capability to support intuitive locomotion in VR environments.



(a) (b)

Figure 4: (a) User's view, and (b) path layout showing a user's single lap result (green: start position and direction; red: user's trajectory).

5 Conclusion

This study presented a DIY WIP interface for VR applications that emphasizes affordability and accessibility. Constructed using inexpensive and readily available materials, the system successfully enables 16 directions of movement and provides intuitive navigation in VR environments. A construction cost of approximately $50 highlights its potential as a low-cost alternative to existing locomotion solutions for VR applications. Additionally, the system eliminates occlusion issues, requires no calibration, and avoids reliance on wearable trackers, making it adaptable to various users and settings.

Although the system performed well in the preliminary demonstration, there were notable limitations. The 16-direction constraint restricts finer granularity in body orientation, potentially limiting its use in precise VR scenarios. The reliance of the system on keeping the left leg centered can cause errors during extended use. Comprehensive user studies are required to evaluate usability and comfort across diverse scenarios. Future research could address these issues by redesigning the pad geometry or adding more sensors to enhance detection granularity and overall performance.

Applications include educational tools, research platforms, and entertainment systems. The capabilities can be extended to more complex VR tasks by improving the pad resolution or layouts, offering a versatile and accessible tool for VR applications.

References

[1] S. Bu and S. Lee. Easy to calibrate: Marker-less calibration of multi-view azure kinect. *CMES-Computer Modeling in Engineering & Sciences*, 136(3), 2023. 1

[2] H. Cherni, N. Métayer, and N. Souliman. Literature review of locomotion techniques in virtual reality. *International Journal of Virtual Reality*, 2020. 1

[3] J. Lee, S. C. Ahn, and J.-I. Hwang. A walking-in-place method for virtual reality using position and orientation tracking. *Sensors*, 18(9):2832, 2018. 1

[4] C. Park and K. Jang. Investigation of visual self-representation for a walking-in-place navigation system in virtual reality. In *2019 IEEE conference on virtual reality and 3D user interfaces (VR)*, pp. 1114–1115. IEEE, 2019. 1

[5] R. Shin, B. Choi, S.-M. Choi, and S. Lee. Implementation and evaluation of walk-in-place using a low-cost motion-capture device for virtual reality applications. *Sensors*, 24(9):2848, 2024. 1

[1] https://www.youtube.com/shorts/xOIdWp9KxaI