Developing an Augmented Reality Tool for Walking and Attention Rehabilitation

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Abstract

Walking rehabilitation post-stroke requires complex motor-cognitive integration. While virtual reality shows potential, safety concerns and challenges with environment complexity and naturalness limit its clinical adoption. This study presents a tool attempting to address these barriers by the use of augmented reality, which maintains the user's view of the real world mitigating these issues. We evaluated the tool's usability and found that the system functioned as planned, without failures or discomfort while utilizing the planned advantages of safety and connection to users' surroundings. These results act as a basis for the next step of testing with a clinical population.

Keywords

Augmented Reality (AR), Rehabilitation, Post-stroke rehabilitation, Attention Rehabilitation, Walking rehabilitation, Mobility.

1. Introduction

Resuming walking after a stroke is not just a motor task, but a complex activity that requires a combination of physical control and cognitive processing Rice et al. (2022) as the real world is full of obstacles and tasks. In practice, many stroke patients have particular difficulty in realistic walking situations that combine attention, navigation, and decision making – that is, in walking under conditions that simulate everyday life. Many studies indicate that encouraging walking in real environments contributes to improved physical, functional, and cognitive outcomes Cho et al. (2015), Miller et al. (2021), but in practice many rehabilitation frameworks often emphasize improvements in controlled clinical settings, with limited transfer to real-world walking Bansal et al. (2024). Moreover, cognitive impairments, such as spatial neglect, reduce mobility, safety, and independence, highlighting the complexity of walking rehabilitation Appelros et al. (2002), Plummer et al. (2013). Therefore a key challenge is not just encouraging the movement in and of itself, but restoring the ability to combine the physical and cognitive demands of real environments.

Virtual reality (VR) has been proposed as a promising tool to address these needs, especially in the context of improving patient engagement and creating interactive-yet-controlled training environments Tunc et al. (2024), Notkin et al. (2026). Studies indicate that the use of VR may improve balance, gait, and motor function, as well as contribute to neuroplastic changes and cognitive engagement Tunc et al. (2024), Wei et al. (2025), Thakur et al. (2025), especially when combined with traditional therapy. In addition, VR allows for immediate multisensory feedback, objective performance monitoring, and personalized training, while creating complex scenarios without the need for extensive physical infrastructure Tunc et al. (2024), Hadjipanayi et al. (2024).

However, despite these advantages, VR has significant barriers that limit its clinical application. Immersive virtual environments may impair interaction with the real world Kouijzer et al. (2023), alter gait patterns De Keersmaecker et al. (2023), and limit the ecological validity of training Kouijzer et al. (2023). In addition, there are safety challenges, spatial constraints, and side effects such as cybersickness Kouijzer et al. (2023), which may affect the patient experience and the ability to apply the technology broadly. As a result, despite the potential, clinical adoption of VR remains limited.

Unlike VR, augmented reality (AR) combines the real environment with virtual stimuli Milgram & Kishino (1994), thus preserving the natural context of walking. This combination allows patients to perform real movement while being exposed to controlled cognitive challenges, without disconnecting them from their surroundings. As a result, AR may improve safety, enable continuous interaction with clinical staff thus reducing the feelings of isolation during training, preserve natural walking patterns, and improve the ecological validity of training. These benefits are also accompanied by a reduction in cybersickness symptoms De Cecco et al. (2023), Navas-Medrano et al. (2024).

To utilize this potential, we developed an AR mobility rehabilitation tool for stroke patients, designed to integrate motor and cognitive demands during real-world walking in a way which connects the patients with their environment. The system utilizes gamified virtual obstacles that encourage patients to navigate around and between them, alongside collectibles and penalties elements that guide path selection and promote goal-directed movement. Finally, we tested the system's usability on a group of healthy participants as a preparatory step for testing it with patients which is currently underway.

2. Methods

2.1. Our tool

Our tool is an AR rehabilitation system that encourages interactive patient movement and spatial attention in hospital environments. We developed it in an iterative fashion with feedback from clinical rehabilitation staff. The software was programmed using Unity (with C#) for the Meta Quest 3 headset, which offers full-color-passthrough AR and enables real-time interaction and tracking. When the user activates the tool, their environment is augmented with collectible targets (e.g. floating coins), objects they must avoid (e.g. floating viruses) and obstacles which they must circumvent (e.g. chairs, monitors). These can be flexibly configured by the therapist before each trial. The object's location and spatial distribution are controlled by the clinical staff to challenge the patients to explore their environment, move through it naturally while collecting and avoiding objects, and focus their attention on different spatial areas of it (e.g. for patients challenged by spatial neglect). The tool can be deployed in any environment, utilizing Meta's scene Mesh, and thus is not locked to a specific hospital or ward. A dedicated Head Up Display (HUD) is implemented to inform the participants of their score in real time (see Fig. 1).

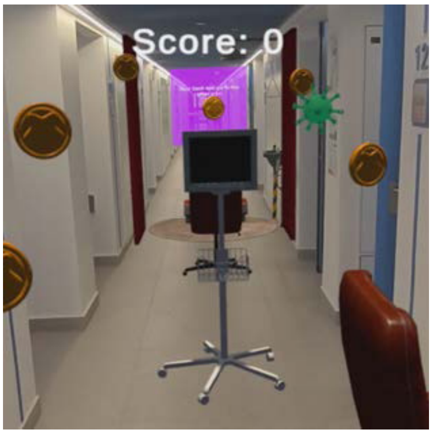

Figure 1: Patient's point of view with the AR content such as coins, viruses, medical monitor, and office chairs using the Meta Quest 3 passthrough.

2.2. Experimental procedure

To assess the technical stability, user experience, and interface clarity of our system before clinical deployment, we conducted a usability study involving 7 healthy participants. The experiment was approved by our university's IRB (Approval No. 1149/25) and all participants signed their informed consent.

The participants first received an explanation of the experiment and gave their informed consent. Each participant performed 3 trials. The experimental environment was a corridor that is 10 meters long and 1.4 meters wide, with virtual elements: 8 collectible coins, 2 penalty viruses and 4 obstacles. The participant dons the headset, and is guided to walk in the corridor back and forth. While walking, the participant is tasked with collecting coins, while avoiding obstacles (e.g., chairs, monitors) and viruses. These objects can be collected by reaching them physically with the controllers or HMD. Objective overall functionality and participant performance were tracked throughout. After completing the task, participants answered a survey consisting of 1–7 Likert scales (with 7 being high) to gather feedback on their experience. Responses were analyzed using a one-tailed Wilcoxon signed-rank test, and all statistical results are reported as mean ± SE.

3. Results

We developed an AR system for motor and cognitive rehabilitation. We activated the system successfully both in lab and clinical settings.

In our usability study, all participants successfully completed three full trials without any technical issues. All customizable features functioned as intended, including trial configuration, stage transitions, dynamic object regeneration, user location and activity logging and live scoreboard tracking. Survey feedback indicated high ease of use (6.7 ± 0.49; $p < 0.01$, effect size $r = .91$ and no symptoms of motion sickness symptoms or discomfort (1 ± 0; 100% consensus), measured on a 1–7 scale (1 = not at all, 7 = very much). Movement trajectory and interaction data indicates active user engagement with collectibles and obstacles throughout the task (see Fig. 2).

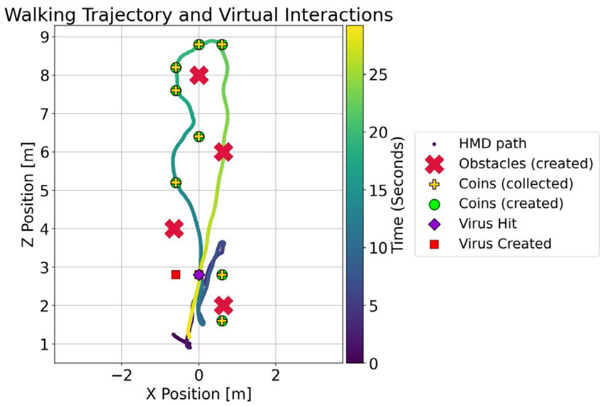

Figure 2: Walking trajectory and virtual object interactions during one trial. HMD position over time, with color indicating elapsed time. Symbols mark virtual elements: red crosses for obstacles, yellow-plusses represent coins that were collected, green circles indicate coins that were created, red squares for created viruses, and purple diamonds for virus collisions.

4. Discussion

The study findings indicate that our AR system is technically and positively received by users. The high level of usability and the absence of discomfort or motion sickness are particularly important in the context of rehabilitation applications, where patient acceptance and cooperation are a prerequisite for the success of the intervention.

The system allows for easy deployment in existing clinical environments, such as corridors of the rehabilitation wards in hospitals, without the need for physical modifications or additional dedicated equipment. This advantage with the possibility to integrate the system into daily rehabilitation routines, supports widespread clinical application.

The use of AR allows users to remain connected to the physical environment, thus potentially improving safety during walking sessions. With the combination of interactivity, real-time feedback, and game elements may increase user engagement, as also found in previous studies in the field.

The system's ability to record events such as collisions, item collection, and spatial navigation with time and location stamps opens up the potential for objective and detailed assessment of user performance, which could be used in the future to develop new digital biomarkers for assessing motor and cognitive function.

However the main limitation of our work is that it is clearly just the first step – our tool must now be tested with patients and must undergo feasibility and clinical efficacy studies, steps which we are now undertaking.

5. Conclusions

This project developed an AR rehabilitation tool for motor and cognitive rehabilitation within real-world hospital environments and evaluated its usability. The findings indicate successful usability and set the stage for the next phases of this project, with emphasis on deploying it with patients and integrating the system into routine workflow with clinicians.

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Disclosure of Interests

The authors declare that they have no competing interests.

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