Leveraging Virtual Reality Simulation to Engage Non-Disabled People in Reflection on Access Barriers for Disabled People

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(a) (b) (c)

Figure 1: Screenshots of the VR environment depicting the ground level (left, center) and the underground tram station.

Abstract

Disabled people experience many barriers in daily life, but non-disabled people rarely pause to reflect and engage in joint action to advocate for access. In this demo, we explore the potential of Virtual Reality (VR) to sensitize non-disabled people to barriers in the built environment. We contribute a VR simulation of a major traffic hub in Karlsruhe, Germany, and we employ visual embellishments and animations to showcase barriers and potential removal strategies. Through our work, we seek to engage users in conversation on what kind of environment is accessible to whom, and what equitable participation in society requires. Additionally, we aim to expand the understanding of how VR technology can promote reflection through interactive exploration.

CCS Concepts

• **Human-centered computing → Empirical studies in HCI**; **HCI theory, concepts and models**; **Virtual reality**; **Accessibility**; • **Applied computing → Computer games**; • **Social and professional topics → People with disabilities**.

Keywords

Access Barriers, Disability, Virtual Reality.

*Authors contributed equally to this research.

Mensch und Computer 2024 – Workshopband, Gesellschaft für Informatik e.V., 01.-04. September 2024, Karlsruhe, Germany

https://doi.org/10.18420/muc2024-mci-demo-303

1 Introduction and Background

Disabled people continue to experience barriers in daily life, for example, with respect to mobility and transportation [1], and general access to the built environment [7]. Viewed through the lens of the social model of disability [13], there is an understanding that societal structures have a disabling effect on individuals, and the need to address these has been widely recognized in legal frameworks such as the UN Convention on the Rights of Persons with Disabilities [10]. However, the encouragement of shared responsibility for accessible environments that effectively involves non-disabled people in the identification and removal of barriers remains challenging.

In the past, there have been attempts to raise awareness for disability and foster empathy toward disabled people through disability simulation [3, 9]. With this method, a non-disabled person is temporarily put in a situation in which they are meant to experience *"what is it like to have a disability"* [4]. Practically, such experiences have been facilitated in-person, or in the context of immersive media, including Virtual Reality (VR) [2]. However, the approach of simulating disability has been criticized extensively by advocacy groups, e.g., see [12, 16]. Additionally, a significant body of academic literature has shown that disability simulation can be ineffective, if not harmful often due to a lack of competence that non-disabled people bring into the simulation (e.g., no experience with the use of assistive devices), which can lead to false assumptions and yield negative feelings such as anger and frustration [4, 9]. Likewise, there is concern about simulations that equate brief engagement with lived experience of disability [8].

At the same time, there is evidence that VR can be an effective tool to stimulate reflection, for example, in the context of breastfeeding [15] or education [14]. In this work, we therefore want to explore an alternative avenue to disability simulation, adopting an alternative approach in which we highlight barriers rather than implying that we can or should simulate the experience of disability.

We do so through a case study of a VR simulation of a popular traffic hub in Karlsruhe, Germany that is known for its complexity and access barriers. Within the simulation, we leverage visual embellishments [6] to focus user attention on the environment rather than on the experience of disability, and we highlight barriers and their removal to promote reflection on what kinds of issues are present in everyday environments, and how they could be addressed through collective action. Through this demo, we aim to expand the understanding of how Virtual Reality (VR) technology can promote shared responsibility for accessible environments, and we want to provide the foundation for further exploration of technology that is capable of promoting reflection.

2 A VR Simulation of Barriers in the Built Environment

The design of the VR simulation aimed to replicate a spot that is familiar to the local community and showcases different barriers that may occur in public spaces. Therefore, we chose the traffic hub *Durlacher Tor*[1] in Karlsruhe, see Figure 1. The general flow of the simulation is as follows: After entering VR, the participants find themselves as pedestrians standing on the sidewalk at the junction. They can move freely and interact with the environment. A visual marker highlights the path to the first barrier. After a barrier is reached, the visual guide switches to the next highlighted barrier. This process continues until all three points of interest are visited.

[1] https://www.google.com/maps/@49.0089334,8.4170876,20.03z?entry=ttu

2.1 System Design

Here, we give an overview of our system design with focus on the simulation site and the integration and highlighting of barriers.

2.1.1 Identification of Simulation Site and Barriers. We chose the simulation site because of its complexity: At Durlacher Tor, multiple tram and subway lines meet; there are several bus stops, motorized traffic flows from multiple directions, and pedestrians and cyclists frequently pass by. Additionally, given its close proximity to local businesses and the university campus, crowding occurs multiple times per day. As a result, there are many known access barriers discussed within the local community, making it a worthwhile site to focus on. Additionally, the geographical proximity of our research group to the hub enabled fast development, and allowed us to check the real site and compare it against our simulation frequently. The total region of the simulation space is approximately 150×150 m.

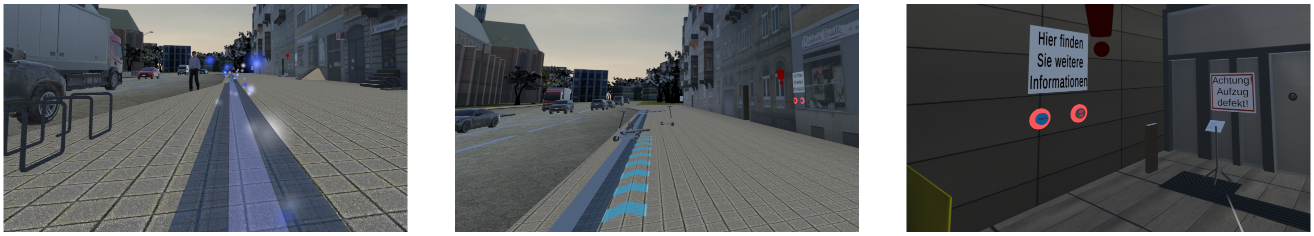
2.1.2 Visual Embellishment of (Removal of) Barriers. To spark the users' reflection processes, the simulation hints the user toward three different barriers in the virtual environment (see Figure 2), and we employ visual embellishments to alert users to their existence: Each barrier is marked with an exclamation mark hovering above it. When the user is in proximity to a barrier, a particle effect starts playing to draw the user's attention toward it. The path towards the barriers is visualized on the ground to guide the player to the barriers.

Barrier 1: Abruptly ending tactile guiding strip. On the sidewalk at ground level, there is a tactile guiding strip that unexpectedly ends without providing any information for a relying person who is blind or has low vision where to go (Figure 2a). Once the barrier was encountered, the simulation places an additional piece of tactile paving to improve access.

Barrier 2: Cluttered sidewalk. The sidewalk is cluttered by scooters (see Figure 2b), which is a challenge for a range of people, including wheelchair users and people who are blind or have low vision. When the user is in proximity, an animation starts, which moves the scooters to the side so that the guide strip and the sidewalk can be safely navigated.

Barrier 3: Broken elevator. One of the elevators to reach the underground station is broken (see 2c), posing a barrier for people with limited mobility. When the user reaches the broken elevator, a sign informs them that it does not work and that they are required to take a different one on the other side of the station. Additionally, moving arrows indicate the way to the alternative elevator.

We selected the initial barriers based on the literature on pedestrian navigation safety [5, 11] and internal discussions. In future work, we want to explore integration of additional barriers that can result from dynamic situations (e.g., crowding), and also include different types of barriers apart from mobility-related ones that can be hindrances on other levels, e.g., sensory barriers, such as crowding and noise, or motor barriers, e.g., intricate input modalities for ticket machines. With this approach, we aim to broaden the perspective on how people experience the world and what constitutes an access barrier.



(a) Barrier 1: Interrupted tactile guiding strip. **(b) Barrier 2: Scooters cluttering the sidewalk.** **(c) Barrier 3: Dysfunctional lift.**

Figure 2: Screenshots of the barriers and highlighting strategies leveraged in the VR environment.

2.2 Technical Implementation

The VR simulation is built using the game engine Unity 3D 2022[2]. To design the virtual environment, we used 3D geographic data provided by the city administration Geoportal Karlsruhe[3]. For the simulation of pedestrians and the traffic, we employed the Mobile Traffic System[4] package, which handles the pathfinding of the road users, the traffic light logic and car overtaking prioritization. To provide a versatile experience, the simulation includes 107 3D models of pedestrians and 19 different car types. We used the original schedule for public transport, resulting in public transport arriving approximately every 5–10 min. For the VR interface, we used the OpenXR framework in conjunction with the Interaction Toolkit and employed the standard controller inputs: left joystick for continuous movement, right joystick for discrete rotation in steps of 45° and the trigger buttons to interact with the environment. The application runs on a desktop PC with NVIDIA GeForce RTX 3070 graphics, Intel i5 11500 processor, and 16 GB RAM. As the VR device, we use the Meta Quest 3 running as a client device via Oculus Link.

3 Outlook and On-Site Demonstration at MuC 2024

In this section, we give an overview of the anticipated setup at the conference and details of the demonstration process. Additionally, we reflect upon the experience that we hope participants will have when interacting with the demo, and we provide guiding questions that we want to explore together with participants.

3.1 Demo Setup and Requirements

We will present the VR experience at the venue. Participants will be invited to try out the demo or observe while the authors demonstrate the application. We anticipate that each participant will need to spend about five minutes in VR. For the installation, we will provide a desktop PC and a VR headset. On-site, we will require a 2×3 m space with a large (35 - 50 inch) display and two tables with three chairs.

[2]https://unity.com
[3]http://geoportal.karlsruhe.de/
[4]https://gleygames.com/traffic-system/

3.2 Participant Experience and Potential for Joint Reflection at the Conference

With this demo, we aim to spark discussions around inclusive design and how VR can leverage a reflection on barriers in public spaces while avoiding harmful effects yielded by disability simulations. We especially invite visitors with disabilities, as well as HCI researchers involved in interaction design for accessibility, to explore the demo and join us in reflecting upon the following issues: What access barriers exist in the built environment, and which ones are commonly overlooked by non-disabled people? What insights can be gained from a VR simulation with respect to barriers? In which way does knowledge transfer to other settings within the simulation and in the real world? What are respect- but insightful ways of communicating barriers in VR, and in how far does such a simulation address shortcomings of disability simulation? And finally, are there risks in our approach to simulating barriers?

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