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Challenges and Technologies for Low-Cost Wheelchair Simulation

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Abstract

The use of electric wheelchairs is inherently risky, as collisions due to lack of control can result in injury for the user, but also potentially for other pedestrians. Introducing new users to powered chairs via virtual reality (VR) provides one possible solution, as it eliminates the risks inherent to the real world during training. However, traditionally simulator technology has been too expensive to make VR a financially viable solution. Also, current simulators lack the natural interaction possible in the real world, limiting their operational value. We present the early stages of a VR, electric wheelchair simulator built using low-cost, consumer level gaming hardware. The simulator makes use use of the the Leap Motion, to provide a level of interaction with the virtual world which has not previously been demonstrated in wheelchair training simulators. Furthermore, the Occulous Rift provides an immersive experience suitable for our training application.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality

1. Introduction

Learning to drive an electric wheelchair can be a dangerous task, both for the user and those around them. Control of a powered chair is often not intuitive, and requires practice, especially for individuals with severe, or multiple motor limitations [Rod15]. Virtual Reality (VR) simulators provide one possible solution, by allowing users to develop skills without the risks inherent to the real world. Studies have demonstrated that virtual wheelchair training interventions, can be effective in training users to control a powered wheelchair [LWCK13]. Considering that in 2005 there was an estimated 1.2 million wheelchair users in the UK alone [SFKG05] (roughly 2% of the population) there is clearly an audience for a dedicated training tool, justifying their ongoing development.

Other users, such as Architects and designers, could also benefit from such simulators, allowing them to test a building's suitability for wheelchair users [SCSIB95], or allow them to experience the challenges these users may face. However, Grant et al. [GHC04] note that the assessment of accessibility requires more realistic models than mere training tools, and should effectively "communicate the experience of wheelchair operation", implying a requirement for a higher level of immersion.

2. Challenges Addressed

Our early stage electric wheelchair simulator, is focused on addressing current challenges, identified by reviewing relevant literature (e.g., [PWRK09, FRL14]):

1. Speed modulation and wheelchair control in spaces with complex spatiality, particuarly crowded areas.
2. Natural interaction and accessibility to physical interfaces such as switches, door handles, swipe card mechanisms etc.
3. Force-feedback interfaces, allowing the user to feel the virtual environment through the wheelchair. While some force-feedback has been shown to be effective in wheelchair simulation [HGC04], it is an area which has received relativity little research in this application.

3. Our Simulator

Our current prototype makes use of low-cost contemporary interfaces, such as the Oculus Rift and the Leap Motion,

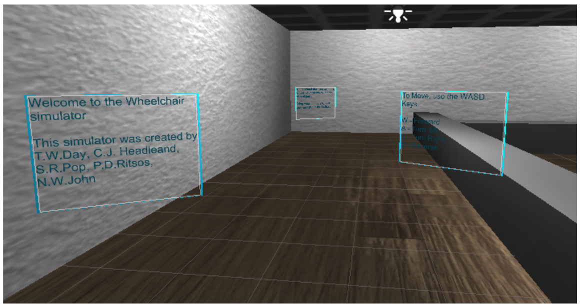

Figure 1: *The users perspective in the first level. The image depicts the instruction cues (teal text) which provide the user with information on how to complete the level.*

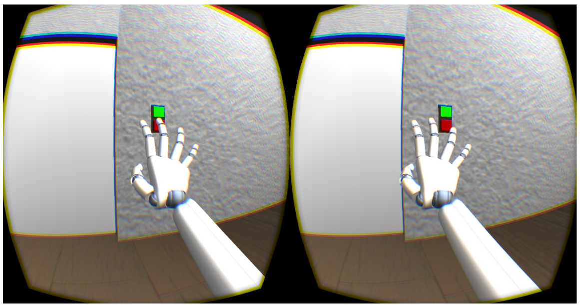

Figure 2: *The view as it is rendered for the Oculus Rift head mounted display. The image shows the user moving their right hand to interact with a door control. Using the Leap Motion hand tracking the users natural gestures are captured and rendered into the virtual world.*

aiming to provide an enhanced sense of presence and simulation fidelity. As the user enters the simulator they are guided through levels of increasing difficulty, each training or developing a specific skill. The user is provided instructions on how to complete each level through cues in the environment (as seen in figure 1).

The user is also able to interact with items in the environment via the Leap Motion. Through this technology they are able to operate interfaces within the environment, such as buttons and access panels (see figure 2).

4. Future Work

Results from early developmental prototypes have been promising, demonstrating that the combination of these low-cost technologies can produce high validity, immersive simulations with training value. We are currently exploring methods to introduce force feedback into the simulator, and this will be the focus of the next major prototype.

We will then undertake a two-stage trial to assess the simulator in terms of the user experience provided. Stage One will involve an evaluation from experts from the field of mobility assistive technologies. The purpose being to validate the accuracy of the simulator and gain further insight into user requirements and needs. Stage Two will involve a series of user trials to assess the training fidelity and effectiveness of the simulator.

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