

Disturbing the Sense of Balance Using Redirection Illusions in Virtual Reality

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Figure 1: (a) The SteppingOn setup has one physical and three virtual stairs. (b) We redirect the user to match the stepping feedback when the user is walking back and forth and collecting apples on the stairs. (c) The application randomly turns off redirection to create a missing step.

1 Reserach Statements

Research in Virtual Reality (VR) and Human-Computer Interaction (HCI) has leveraged human’s perceptual abilities to induce VR illusions — an imperceptible manipulation on the user’s body motions that dominantly aims for positive purposes. For example, providing haptic feedback [1], enhancing presence [4], and improving ergonomics in VR [3]. However, this technological paradigm often fails to consider its potential for malicious design. The field of VR and HCI currently has a lack of understanding to what degree an application could abuse or misuse a VR redirection illusion to result in potential physiological harm to the user.

In this work, we aim to explore and demonstrate the potential of using redirection techniques in VR leading to physio-

logical harm (e.g., losing balance or even falling over). We combined redirected walking and haptic retargeting to implement SteppingOn (Please see the demo video¹ for more details.). The setup (Figure 1a) contains one physical stair functioning as a prop in the real world to support the haptic feedback of three virtual stairs in VR (haptic retargeting). The user has to walk towards the three virtual stairs to pick apples from the trees and return to the original point to put the apple in a basket (Figure 1b). Our game always redirects the user towards the same stair (redirected walking) while having the impression of visiting a different pair of stairs each time. During the game, the application randomly turns off the redirection so that the user deviates from the targeted physical stairs and makes a missing step (Figure 1c). This effect is similar to the moment of climbing stairs, where we think there is one more tread, but we are already standing at the landing, therefore, making an additional step.

Due to the high risk of getting people out of balance, we did not perform an evaluation but did a self-experiment. The difference between a self-experiment and an actual user study is that we have already been exposed to the missing step during the developing process. We understand the effect that we

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¹SteppingOn demo video.

are creating and what we are going to experience. Therefore the use the random stopping to show our application is able to elicit the missing step. While we did know that the redirection would be off at one point, we did not know when this would happen. This resulted in us ($n=5$) still being surprised by the missing step and sometimes even triggering small forms of a stumble. The effect could easily be increased using a larger stair. Inducing any form of harm to participants for conducting this type of research always has ethical concerns. Previous work used biomechanical simulation to investigate the mid-air interaction and fatigue [2]. In the future, we are hoping to be able to simulate the user's body movement in order to evaluate this type of VR application.

The main goal of our work is to demonstrate how techniques that are currently presented within the field of VR and HCI could potentially be abused by malicious forces. We also attempt to raise a discussion on the following aspects: 1) Demonstrate how current interaction techniques in VR could be potentially abused by malicious actors; 2) Start an exploration of the different types of potential harm that could be resulting from the use of VR illusions; and 3) Start a discussion around how we have to improve our current safety mechanisms to avoid these types of abusive designs.

References

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