Proceedings of the 11th World Congress on Electrical Engineering and Computer Systems and Sciences (EECSS'25)
Paris, France - August, 2025
Paper No. MHCI 118
DOI: 10.11159/mhci25.118

Perceptual Calibration of Gravitational Constants in Virtual Environments

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Extended Abstract

Users experience virtual realities (VR) differently and engage with them primarily due to the immersion they provide (Yee, Bailenson, and Ricci, 2006). To enhance the immersive experience, VR allows designers to manipulate gravitational settings. Gravity, as a fundamental force, plays an essential role in how we perceive and interact with the environment. Deviations from gravity in VRs can cause dissonance for users. Han, Kim, and Lee (2021) and Usoh, Catena, Arman, and Slater (1999) stated that when gravity diverged too much from the original, users experienced reduced realism. This has led to digital game players experiencing bizarre feelings, such as unnatural character movements in unnatural gravity settings in VR. Therefore, this paper aims to discover the proper gravity constant that makes a VR more realistic.

We ran experiments with dropping objects in VR at different speeds and let participants select the one they felt was most natural to understand the ideal gravity strength for users to feel the most realistic. We experimented with twenty university students (10 male, 10 female, aged between 20 and 30). The VRs were created with the Unreal Engine 5; both participants experienced using the Head Mounted Display (HMD) (Oculus Meta Quest 2) device. First, participants were presented with a static scene for 5 minutes to help them familiarize themselves with the VR, as Horsak, Schwab, Baca, Hoerbst, Wiegand, and Seewald (2021) advised. Secondly, participants observed a grey sphere (diameter: 0.5 meters, friction coefficient: 0) dropping from a height of seven meters, and interviewed whether the dropping sphere made them feel natural based on the discussion by Menck, Waltemate, and Botsch (2023). We selected four gravity constants: 0.5G, 0.7G, 1G (Earth baseline), and 1.2G. The order of spheres was random to present to participants. After completing each set of experiments, participants were asked to reflect on their experience and respond to the question, "Which gravity setting felt the most realistic?" Responses and subjective impressions were recorded manually.

Nearly half (47%) selected 1.2G, about a third (29%) selected Earth gravity (1G), and the lighter settings, 0.7G (16.3%), 0.5G (7.5%), were rarely selected. The data indicate that a slightly stronger gravity, around 20% above Earth's, makes motion feel more realistic. These findings have practical implications for VR developers and designers, especially in fields where realistic interaction is essential. While this study provides novel insights, it is limited by the sample size and the range of gravity settings tested. Expanding the participant pool and exploring additional gravity settings (e.g., between 1.2G and 2G) could further clarify the impact of gravity manipulation on realism.

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