A Study on Visual Perturbations Effect on Balance in a VR Environment

Markus Santoso
University of Florida, USA

David Phillips
Montclair State, USA

EXECUTIVE SUMMARY

Users sometimes lost their balance or even fell down when they played virtual reality (VR) games or projects. This may be attributed to degree of content, high-rate of latency, coordination of various sensory inputs, and others. The authors investigated the effect of sudden visual perturbations on human balance in VR environment. This research used the latest VR head mounted display to present visual perturbations to disturb balance. To quantify balance, measured by double-support and single-support stance, the authors measured the subject's center of pressure (COP) using a force plate. The results indicated that visual perturbations presented in virtual reality disrupted balance control in the single support condition but not in the double support condition. Results from this study can be applied to clinical research on balance and VR environment design.

ORGANIZATION BACKGROUND

The University of Florida is a public land-grant, sea-grant and space-grant research university on a 2000-acres campus in Gainesville, Florida. It is a senior member of the State University System of Florida that traces its origins to 1853, and has operated continuously on its Gainesville campus since September 1906. The University of Florida is one of sixty-two elected member institutions of the Association of American University (AAU), the association of preeminent North American research universities, and the only AAU member university in Florida. The university is classified as a Research University with Highest Research Acticity by the Carnegie Classification of Institution of Higher Education ("The Carnegie Classification of Institution of Higher Education," n.d.). After the Florida state legislature's

creation of performance standards in 2013, the Florida Board of Governors designated the University of Florida as one of the three "Preeminent Universities" among the twelve universities of the State University System of Florida. For 2019, *U.S. News & World Report* ranked the University of Florida as the eighth (tied) best public university in the United States. The University of Florida is home to sixteen academic colleges and more than 150 research centers and institutes.

Montclair State University (MSU) is a public research university located in the Upper Montclair section of Montclair, at the intersection of the Great Notch area of Little Falls, and the Montclair Heights section of Clifton, in the U.S state of New Jersey. Montclair State University is the second largest university in New Jersey. As of October 2017, there were 21,013 total enrolled students: 16, 852 undergraduate students and 4,161 graduate students. The campus covers approximately 500 acres, inclusive of the New Jersey School of Conservation in Stoke State Forest ("Montclair State University," n.d.). The University attracts students from within the state, from many other states in the Northeast and elsewhere, and many foreign countries. More than 300 majors, minors and concentrations are offered. The university is a member of professional organizations such as the American Association of State Colleges and Universities, American Council on Education, Association of American Colleges and Universities and the Council of Graduate Schools. The university has consistently ranked among the top 100 public universities in the United States in the past few years. In 2017, the university was designated as a R3 Doctoral Research University ("Montclair State University," n.d.).

INTRODUCTION

People live in the three-dimensional (3D) physical world and traditional two-dimensional (2D) flat images such as photo or video are lack of the third dimension information (Geng, 2014). Almost half of human brain capacity is devoted to process visual information and the limitation of flat images and 2D displays will limit human's ability to understand the complexity of real-world objects (Geng, 2014). On the other hand, 3D display technologies improve perception and interaction with 3D scenes, and hence can make applications more effective and efficient (Mehrabi et al., 2013). Driven by the rapid improvement of computer technology, 3D display has become more powerful, affordable and comfortable. One of the 3D displays that widely adopted is stereoscopic display. Stereoscopic is recognized as one of the oldest 3D display systems and it was first proposed by C. Wheatstone in 1838. This type of display was based on stereopsis, where an observer's left and right eyes receive different perspectives separated by a stereoscopic device that the observer is wearing (Nam Kim et al., 2013). One of the stereoscopic displays is anaglyph (Image 1a in Figure 1) that use two color filtered images and glasses that usually utilize red-cyan, red-green, green-magenta and magenta-cyan colors. The other is LC shutter system or also known as active-shutter system (Image 1b in Figure 1). It is defined as a stereoscopic technique that sends the left image to the left eye while the right eye's view is blocked by the display device and user glasses, then presents the right image to the right eye while the left eye's view is blocked (Turner & Hellbaum, 1986). Stereoscopic display can also use a polarized 3D system (Image 1c in Figure 1), a technique that send polarized images to the corresponding eyes through polarization glasses (Nam Kim et al., 2013).

The other stereoscopic technique is head-mounted display (HMD). HMD is a device worn on the head, or as part of a helmet, it has a small optic display in front of each eye (Nam Kim et al., 2013). HMDs may also be equipped with additional sensors or features such as head-tracking to enable the 3 degree-of-freedom (DoF) that allow user to have 'look around' the virtual world with their head orien-