

Providing safer Virtual Reality experiences with the help of Brain- Computer Interfaces

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, *Carlos Alfredo Tirado Cortes* declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the *School of Computer Science, Faculty of Engineering and Information Technology* at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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*To my mom, my dad, and my brother, for their infinite love and support on all my crazy
endeavours and ideas. . . .*

LIST OF PUBLICATIONS

Journal :

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2. **C. A. TIRADO CORTES**, H. CHEN, TIEN-THONG NGUYEN DO & CHIN-TENG LIN, *EEG Signals and Body Kinematics During Different Levels of VR Sickness*, **Frontiers in Virtual Reality**. (*under review*).
3. NEGIN HESAM-SHARIATI; TOBY NEWTON-JOHN; AVINASH K. SINGH; **C. A. TIRADO CORTES**; TIEN-THONG NGUYEN DO; ASHLEY CRAIG; JAMES W. MIDDLETON; MARK P. JENSEN; ZINA TROST; CHIN-TENG LIN; SYLVIA M. GUSTIN, *Evaluation of the effectiveness of a novel brain-computer interface neuromodulative intervention to relieve neuropathic pain following spinal cord injury: protocol for a single-case experimental design with multiple baselines*, **JMIR Publications**. (*accepted*).

Conferences :

1. **C. A. TIRADO CORTES**, H. CHEN & CHIN-TENG LIN , *Analysis of VR sickness and gait parameters during non-isometric virtual walking with large translational gain*, Proc. 17th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and its Applications in Industry (**VRCAI 2019**), Article 16, pp. 1 - 10, Brisbane, Australia, November, 2019.
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Others :

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ABSTRACT

With the introduction of Virtual Reality (VR) to the mass market, two of the most significant issues affecting its users have come to light: Virtual Reality Sickness and Postural Instability. These issues have led to a low acceptance rate from consumers towards the VR market, preventing it from growing to its full potential. These issues affect everyone from VR application developers, research projects using VR for different purposes, and the average consumer who wants to use it for recreational purposes. This research project focuses on tackling these issues in two of the most common setups: stationary and non-stationary.

Stationary setups already have a track of works that accurately detect both VR sickness and postural instability. Even VR sickness has a track of different creative methods to mitigate it once detected. Nevertheless, there isn't a clear definition of what can be used to help if a user suffers from postural instability or even a fall. For that reason, this project developed and tested two different methodologies for balance recovery: auditory warning and turning the headset's camera on. Results showed that these techniques activated up to 500 ms before the fall onset is enough to prevent users from losing balance.

For mobile VR setups, it is unclear if the same detection methodologies as in stationary setups. Following previous works that use a combination of electroencephalography (EEG) and full-body motion capture suits, this research project intends to use these technologies to identify VR sickness and postural instability in mobile setups and their difference with stationary setups.

The results confirmed that, on non-stationary setups, users' postural instability could be measured by the changes in their Center of Mass and the changes in EEG signals. Results on VR sickness signals showed that other cognitive processes influence non-stationary VR signals compared to stationary VR signals.

These findings can collectively set the building blocks for developing closed-loop systems that can adequately monitor users, detect the appearance of these issues, and provide a solution to either mitigate or avoid these issues. Ultimately, providing an overall safer VR experience to all VR users.

