Submission Overview

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Article Type	Regular Manuscript
Title	Simulation and Classification of Spatial Disorientation in a Flight use-case using Vestibular Stimulation

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submission_main_manuscript_j04m03a22.pdf	Main Document - PDF	4.2 MB	Initial Submission
submission_author_bios_and_photos_j	Author Bios and Photos	568.5 KB	Initial Submission

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03m03a22.doc			
cover_letter_j04m03a22.pdf	Cover letter / Comments	707.9 KB	Initial Submission

Abstract

In aeronautics, spatial disorientation (SD) is "an erroneous sense of one's position and motion relative to the plane of the earth's surface" [1]. SD has a wide range of situations and factors, but mainly it has been studied using reduced experimental contexts such as motion detection experimentation in isolation. Because there are many SD use-cases that are studied in isolation in a reduced manner, it is difficult to develop a generalized and fundamental understanding of the occurrence of SD and viable solutions. To investigate SD in a generalized manner, a two-part neuroergonomics study consisting of an in-flight piloting use-case experiment and machine learning (ML) model prediction was performed. The first part of the study was the creation of a generalized SD perception dataset using whole-body experimental motion detection methods in a naturalistic flight context; participant perceptual joystick response was measured during rotational or translational vestibular stimulation. The second part of the study consisted of ML parameter tuning selection for SD prediction, using joystick response-derived features from the generalized SD perception dataset. Additional measures of SD were investigated for future ML feature usage, such as questionnaire-based physical disorientation measured using the simulator sickness questionnaire (SSQ) disorientation sub-scale. The perceptual SD dataset was statistically proven to be representative of human motion detection behavior, demonstrating that the simulation environment was sufficient to generate a fidel SD context. ML modeling comparison analysis demonstrated that SD can be accurately predicted regardless of the feature quantity used, however model type, specialized dataset models, feature type, and label type significantly influence prediction accuracy. Finally, no significant relationship between physical disorientation and motion detection was found, indicating that two-sample before and after SSQ questionnaire-based methods are insufficient to uncover correlations with perceptual disorientation; a more frequent physical disorientation measure is needed.

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Aircraft navigation; Human computer interaction; Machine learning algorithms; Motion detection; Dead reckoning

Subject Category

Systems, man, and cybernetics; Computational and artificial intelligence; Signal processing; Intelligent transportation systems; Aerospace and electronic systems

Has this manuscript been submitted previously to this journal?

No, it wasn't submitted previously

Informed Consent

Yes, human subjects were involved

Yes, I have stated that Informed Consent was obtained, or provided an explanation in my Methods section.

Animal Subjects

There were no animal subjects

Do you or any of your co-authors have a conflict of interest to disclose?

No, there is no conflict of interest

Suggested Reviewers
No response provided

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No response provided

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Research Article

Justification

We have chosen to submit our manuscript as a "Research Article" because it is the ideal research format for our contribution with hypothesis, investigation, solution, physical experiment & simulation, and modeling. The authors believe that the result of this work is of value to experts and researchers in the field of spatial disorientation, aeronautics, prediction of human motion detection, perception and action in general beyond the field of aeronautics.

Scope

This work is within the scope of IEEE Access because it investigates the interdisciplinary topic of spatial disorientation for a simulated flight use-case. This study of spatial disorientation included the usage of information from the research fields of aeronautics, human physiology and psychology, linear control theory, statistics, and artificial intelligence. To the understanding of the authors, IEEE Access desires articles similar to our work because the content is original and multidisciplinary, technically correct to the authors knowledge, and presented in a clear manner.

Unique Contribution

The unique contribution of this work is to show that SD can be predicted and thus monitored using task performance and human movement measures. In order to reach this objective, we use a machine learning method coupled to a psychophysical experimental approach with additional data modeling techniques, applied to the field of spatial disorientation in an aviation context. The machine learning and experimental techniques are not entirely novel, however their combination and the application of our techniques to predict SD from human motion are novel.

Decision Letter

Review decision letter

History

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