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Development of a Virtual Environment-Based Electrooculogram Control System for Safe Electric Wheelchair Mobility for Individuals with Severe Physical Disabilities

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Keywords: Electrooculogram; Wheelchair; Classification; Virtual Environment; Safety; Control.

Abstract

Conventional wheelchairs are predominantly manual or joystick-operated electric wheelchairs. However, operating these wheelchairs can be difficult or impossible for individuals with severe physical disabilities. Due to losing control of their physical limbs, they depend on an attendant for assistance. As a remedy, bio-signals may be used as a control mechanism since they are readily available and can be acquired from any body part. This research proposes to use EOG signals to vail a control mechanism and test it in a virtual and actual electric wheelchair. The main contribution of the study is an investigation of the use of EOG to control an electric wheelchair in a virtual environment to determine safe control parameters for wheelchair use in complex environments. A customized data acquisition circuit was developed to acquire single-channel EOG signals using wet electrodes. The acquired signal was filtered and processed using feature extraction and classification techniques in MATLAB software. Two customized control environments were developed in Unity 3D, one with equally partitioned sections and the other with sections decreasing in size as the robot wheelchair approaches the target. Twenty-two test subjects (mean age 24.5, std 1.5) participated in the study, controlling the robot wheelchair in real-time with non or least instances of collision and oversteering. The system achieved an accuracy of 96.5% with a response time of 0.7s, translating to an ITR of 70.6 bits/min. Overall, the participants

managed to navigate the virtual environment with a completion time of 101.94s ± 19.71 and 109.07s ± 13.25 for the male and female participants, respectively. In the scene with decreasing section sizes, 72% and 54% instances of collision and oversteering were reported, respectively, highlighting the need to consider the complexity of the control environment and the sufficiency of the participants' control skills to ensure safety in operations. The results confirm the usefulness of EOG as a control interface, with little or no need for recalibration. It provides a promising avenue for individuals with severe physical disabilities to operate wheelchairs independently in complex environments, enhancing their quality of life.

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