BMCI-Net: A Novel Approach to Non-Invasive, Fully Mobile Prosthetic Control Using Robust Pattern Detection and Filtration of EMG and EEG Signals through Supervised Machine Learning

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Current state-of-the-art prostheses require invasive surgical procedures which can pose risks to the patient, while on the other hand, non-invasive prosthetic technology lacks accurate pattern detection, rapid classification schemes, and robust training efficiency. In order to redress the weaknesses of non-invasive prosthetic technology, BMCI-Net takes a novel approach by aggregating and processing electroencephalogram (EEG) and electromyography (EMG) signals to effectively classify sensory events via supervised learning. Signal acquisition was conducted with the Emotiv EPOC+ and Arduino Myoware modules and integrated through an XBee communication network. Noise filtration of artifacts was implemented through low-pass and high-pass filters in tandem with epoching of the signal in fixed intervals. EEG signals were further processed through a Butterworth filter and Common Spatial Pattern technique, whereas EMG signals underwent wavelet transform along with integrated rectification envelope and subsequent peak analysis. Correlation between heart rate and signal amplitude was observed and termed cardio-stress amplification. The classification scheme was carried out through a Deep Feedforward Neural Network employing a 3-layer sequential model with rectifier and sigmoid activation functions, 'Adam' stochastic optimization, and a binary cross-entropy logarithmic loss function to classify three activities: finger-flexion, finger-extension, and idle state. Five trials were conducted comparing EEG signals, EMG signals, and the combined BMCI-Net technique and results indicated that the BMCI-Net method is more accurate than just a simple BCI or MCI. Therefore, our study paves the way for a novel application of a brain-muscle-computer interface in the field of prosthetic design.

Awards Won:

Second Award of $1,500

National Aeronautics and Space Administration: Second Award of $750