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Towards Real-Time Classification of Finger Movement Direction Using Encephalography Independent Components

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Abstract : This study explores the practicality of using electroencephalographic (EEG) independent components to predict eight-direction finger movements in pseudo-real-time. Six healthy participants with individual-head MRI images performed finger movements in eight directions with two different arm configurations. The analysis was performed in two stages. The first stage consisted of using independent component analysis (ICA) to separate the signals representing brain activity from non-brain activity signals and to obtain the unmixing matrix. The resulting independent components (ICs) were checked, and those reflecting brain-activity were selected. Finally, the time series of the selected ICs were used to predict eight finger-movement directions using Sparse Logistic Regression (SLR). The second stage consisted of using the previously obtained unmixing matrix, the selected ICs, and the model obtained by applying SLR to classify a different EEG dataset. This method was applied to two different settings, namely the single-participant level and the group-level. For the single-participant level, the EEG dataset used in the first stage and the EEG dataset used in the second stage originated from the same participant. For the group-level, the EEG datasets used in the first stage were constructed by temporally concatenating each combination without repetition of the EEG datasets of five participants out of six, whereas the EEG dataset used in the second stage originated from the remaining participants. The average test classification results across datasets (mean ± S.D.) were 38.62 ± 8.36% for the single-participant, which was significantly higher than the chance level (12.50 ± 0.01%), and 27.26 ± 4.39% for the group-level which was also significantly higher than the chance level (12.49% ± 0.01%). The classification accuracy within [–45°, 45°] of the true direction is 70.03 ± 8.14% for single-participant and 62.63 ± 6.07% for group-level which may be promising for some real-life applications. Clustering and contribution analyses further revealed the brain regions involved in finger movement and the temporal aspect of their contribution to the classification. These results showed the possibility of using the ICA-based method in combination with other methods to build a real-time system to control prostheses.

Keywords : brain-computer interface, electroencephalography, finger motion decoding, independent component analysis, pseudo real-time motion decoding
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