Accepted Manuscript

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PII: S0165-0270(18)30173-0
DOI: https://doi.org/doi:10.1016/j.jneumeth.2018.06.003
Reference: NSM 8025

To appear in: *Journal of Neuroscience Methods*

Received date: 9-2-2018
Revised date: 7-6-2018
Accepted date: 7-6-2018

Please cite this article as: G R Kiran Kumar, M Ramasubba Reddy, Periodic component analysis as a spatial filter for SSVEP-based brain-computer interface, *<![CDATA[Journal of Neuroscience Methods]]>* (2018), https://doi.org/10.1016/j.jneumeth.2018.06.003

Periodic component analysis as a spatial filter for SSVEP-based brain-computer interface

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Abstract

Background: Traditional Spatial filters used for steady-state visual evoked potential (SSVEP) extraction such as minimum energy combination (MEC) require the estimation of the background electroencephalogram (EEG) noise components. Even though this leads to improved performance in low signal to noise ratio (SNR) conditions, it makes such algorithms slow compared to the standard detection methods like canonical correlation analysis (CCA) due to the additional computational cost.

New method: In this paper, Periodic component analysis (πCA) is presented as an alternative spatial filtering approach to extract the SSVEP component effectively without involving extensive modelling of the noise. The πCA can separate out components corresponding to a given frequency of interest from the background electroencephalogram (EEG) by capturing the temporal information and does not generalize SSVEP based on rigid templates.

Results: Data from ten test subjects were used to evaluate the proposed method and the results demonstrate that the periodic component analysis acts as a reliable spatial filter for SSVEP extraction. Statistical tests were performed to validate the results.

Comparison with existing methods: The experimental results show that πCA provides significant improvement in accuracy compared to standard CCA and MEC in low SNR conditions.

Conclusions: The results demonstrate that πCA provides better detection accuracy compared to CCA and on par with that of MEC at a lower computational cost. Hence πCA is a reliable and efficient alternative detection algorithm for SSVEP based brain-computer interface (BCI).

Keywords: Steady-state visual evoked potential (SSVEP), Electroencephalogram (EEG), Periodic component analysis (πCA), Canonical correlation analysis (CCA), Brain-computer interface (BCI).

1. Introduction

Motor neuron disorders (MNDs) and spinal cord injuries cause motor disabilities that can prevent the brain from interacting and controlling the external environment using its normal physiological pathways [14]. In such instances, Brain-computer interfaces (BCIs) provide an alternative non-neuromuscular route towards communicating with the environment [27]. Thus, BCIs have the potential to drastically improve the quality of life of users with the loss of neuromuscular control. Since BCIs are required to respond to user intent rapidly, electroencephalogram (EEG) acts as an optimal candidate due to its good time resolution, relatively low cost and portability. Common EEG components used to translate user

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