

Emotion classification in Parkinson's disease by higher-order spectra and power spectrum features using EEG signals: A comparative study

Abstract

Deficits in the ability to process emotions characterize several neuropsychiatric disorders and are traits of Parkinson's disease (PD), and there is need for a method of quantifying emotion, which is currently performed by clinical diagnosis. Electroencephalogram (EEG) signals, being an activity of central nervous system (CNS), can reflect the underlying true emotional state of a person. This study applied machine-learning algorithms to categorize EEG emotional states in PD patients that would classify six basic emotions (happiness and sadness, fear, anger, surprise and disgust) in comparison with healthy controls (HC). Emotional EEG data were recorded from 20 PD patients and 20 healthy age-, education level-and sex-matched controls using multimodal (audio-visual) stimuli. The use of nonlinear features motivated by the higher-order spectra (HOS) has been reported to be a promising approach to classify the emotional states. In this work, we made the comparative study of the performance of k-nearest neighbor (kNN) and support vector machine (SVM) classifiers using the features derived from HOS and from the power spectrum. Analysis of variance (ANOVA) showed that power spectrum and HOS based features were statistically significant among the six emotional states ($p < 0.0001$). Classification results shows that using the selected HOS based features instead of power spectrum based features provided comparatively better accuracy for all the six classes with an overall accuracy of $70.10\% \pm 2.83\%$ and $77.29\% \pm 1.73\%$ for PD patients and HC in beta (13-30 Hz) band using SVM classifier. Besides, PD patients achieved less accuracy in the processing of negative emotions (sadness, fear, anger and disgust) than in processing of positive emotions (happiness, surprise) compared with HC. These results demonstrate the effectiveness of applying machine learning techniques to the classification of emotional states in PD patients in a user independent manner using EEG signals. The accuracy of the system can be improved by investigating the other HOS based features. This study might lead to a practical system for noninvasive assessment of the emotional impairments associated with neurological disorders.

Keywords — Bispectrum, EEG, emotion, Parkinson's disease, pattern classification, power spectrum