ABSTRACT

KEYWORDS: EEG; Second-order statistics; Covariance; Multivariate Fourier Decomposition Method; Sparse iterative covariance-based estimation approach; Likelihood-based Estimation of sparse parameters, MEMD, MFDM, MVMD, Graph Signal Processing.

Localizing the active brain source using EEG signals is gaining a lot of interest from researchers. EEG signals are non-invasive, easy to capture, and economically feasible. Furthermore, these signals have better temporal resolution than MRI, CT scans, PET scans, etc. EEG signals have lower spatial resolution due to loss of signal as it travels from brain to electrode. So, with EEG source localization, the aim is to improve the spatial resolution of EEG signals.

In this work, second-order statistics have been proposed to enhance the aperture of the electrodes using the concept of virtual electrodes. With these virtual electrodes, a greater number of active sources can be estimated and localized with fewer electrodes.

New covariance-based methods are proposed for EEG source localization, like SPICE (Sparse Iterative Covariance-based Estimation) and LIKES (LIKelihood-based Estimation of Sparse parameters). These methods are robust to noise and improve the source localization results.

Since EEG signals are highly affected by noise, decomposition-based methods like MEMD (Multivariate Empirical Mode Decomposition), MVMD (Multivariate Variational Mode Decomposition), and MFDM (Multivariate Fourier Mode Decomposition) have been used as a preprocessing step, and then the signals are localized. Further, by using these decompositions, the decomposed signal components corresponding to various sources are obtained. From these decomposed signal components, the source-related components are chosen. For the selection of the source-related components, various metrics like kurtosis, skewness, and entropy are studied and used.

Since EEG signals are multidimensional with information in time, frequency, trial, subject, etc. So in the next problem, the EEG source localization was done in the tensor domain. The various decomposition methods gave better results than directly applying source localization. So, these decomposition methods are used to obtain information in the frequency domain. Hence, the tensor is formed using information in channels, electrodes, and IMFs. This tensor is decomposed using the Canonical Polyadic Decomposition method (CPD), and the results are localized using the source-related spatial information used after decomposing.

Till now, the connectivity of underlying sources has not been considered. So, in the next step, the connection of the sources is considered using graph signal processing. Using these concepts, the modified optimization problem is obtained. This problem is solved using FISTA.