Ocular artefact removal from multi-channel EEG data with tensor decomposition

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Abstract.

Removing the effect of ocular artefacts in electroencephalogram (EEG) analysis is an essential preprocessing step. In addition to traditional approaches such as independent component analysis and regression-based algorithms, tensor decomposition methods are receiving increasing attention in ocular correction [1, 2]. Within this approach, a multichannel EEG signal is transformed into a higher-order array (tensor), for example, by the wavelet transformation [1, 2]. However, we prefer to use the nonnegative spectrum of the windowed multichannel EEG signal concatenated into a three-way array [3, 4], offering a better neurophysiological interpretation of the tensor and the following steps of the algorithm.

The tensor is then decomposed into a set of latent components by a tensor decomposition method - the parallel factor analysis [5] or the Tucker model [6]. Latent components are visually inspected for blink-related properties in the time, space, and frequency domains. After identifying and removing components representing ocular activity, the cleaned tensor is transformed into the time-space domain, either by the inverse wavelet transform in [2] or by a version of the Griffin-Lim algorithm [7] within our algorithm.

This study focuses only on one specific step within the algorithm - the component removal from the EEG tensor. Three approaches are considered: i) component zeroing [2], ii) component subtraction from the tensor, and iii) tensor projection onto a nullspace of a component subspace [1]. Since numerical stability and component interpretability are usually achieved by applying different constraints to the tensor decomposition [4], these approaches are compared theoretically and when applied to real eye-blink corrupted EEG data under the assumption of component nonnegativity *by focusing on the ability i) to remove visible eye-blinks, ii) to keep the original signal on non-blink intervals without changes, and iii) to replace the eye blinks with signal following natural EEG properties, both visually and numerically.*

Component zeroing altered the amplitude of EEG and produced signal modification, also on non-blink intervals resulting in an unnaturally flat reconstructed signal. Component subtraction and projection follow similar mathematical formulas under the premise of component orthogonality. However, the projection approach led to inferior results when the latent components were assumed to be nonnegative, and component subtraction is preferred in this case.

Keywords: *tensor decomposition, latent component removal, eye blink correction, electroencephalogram*

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