Noise Reduction in Visual Evoked Potential Signals Using Two-Levels of Principal Component Analysis

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VEP signals consists of oscillating potentials derived from the scalp surface using electrodes and are believed to originate from the neurons in the cortex (outer layer of the brain). They are a specific type of electroencephalogram (EEG) signal and are evoked during the perception of visual stimulus like seeing a picture. VEP signals have been applied in numerous neuropsychological studies and clinical purposes. An artifact that corrupts VEP signals is background EEG and averaging from multi-trials is commonly used to solve this problem because VEP signals are time-locked to the stimulus, thereby adding up with averaging while EEG will be reduced due to its random property. However, this results in averaged VEP and analysis on a single trial basis cannot be performed.

In this Letter, two-levels (i.e. two consecutive applications) of Principal Component Analysis (PCA) are used to reduce noise from multi-channel and multi-trial Visual Evoked Potential (VEP) signals. PCA is a technique that has been used for noise reduction but application of two-levels of PCA is novel. In the first level, PCA is applied to multi-channel VEP signals from one trial. The output VEP signals from the first level are used in the second level, where PCA is applied to multi-trial VEP signals from a single channel. The ability of PCA to reduce noise stems from the fact that multi-channel and multi-trial VEP signals are more correlated as compared to noise during visual perception. Simulation study using emulated and real VEP signals contaminated with noise shows significant improvement in signal to noise ratio (SNR) with the application of the two-level PCA.