Sparse inverse time correlation model for signal identification in functional Near Infrared Spectroscopy data

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Abstract: Functional near infrared spectroscopy (fNIRS) uses the absorption of near infrared light by hemoglobin to record changes in blood oxygenation as signals of functional brain activity. For designs in which subjects are instructed to execute a specific mental task under different experimental conditions with pre-determined levels for covariates, fNIRS provides real-time cerebral hemodynamic responses for studying neural correlates of task-related experimental variables. Data obtained from such designs are discretized observations of the hemodynamic curves on a high-resolution time scale. Testing for overall group mean differences among curves or, more generally, relationships between curves and explanatory variables can be addressed by using functional Analysis of Variance (fANOVA) procedures in a general multivariate linear regression framework where additional assumptions are made to account for the regularity of mean curves and for the strong time-dependence across residuals.
Causeur *et al.* (2020) demonstrated that how way time dependence is modeled in such fANOVA testing procedures is crucial and should account for the interplay between the pattern of regression parameter curves and the distribution of the time correlations. To address the challenging issue of identifying time points for which the association signal is nonzero, we propose a doubly penalized estimation procedure assuming that both the association signal and the inverse time correlation matrix are sparse. We show how the tuning of penalty parameters enables a flexible handling of dependence and deduce optimal signal identification procedures.

Key words: Functional data; fNIRS data; Inverse correlation model; High-dimensional data; Penalized estimation.

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