Penalised Iterative Sparse Partial Correlation Estimation (Π-SPaCE)

- with an application to whole-brain graph estimation

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Abstract

Sparse matrix estimation is often used in network science including neuroscience, social network, and genomic study, where the networks are high-dimensional and sparse. Graph estimation is subsequently used to numerically and visually delineate the networks between different brain voxels, individuals, or genes. While there has been significant research on the topic in recent years, most existing methods require pre-selecting the non-zero support set of the correlation matrix, or entailing a time-consuming block-wise estimation fashion. As a motivating example, consider a functional magnetic resonance imaging (fMRI) study of thermal pain where, while we have little prior information of the non-zero support brain regions, we are interested in determining the whole-brain network (between hundreds of thousands of voxels) under thermal treatment. To address the problem of ultra-high-dimensional network estimation where little prior information is present, we propose a framework called the Penalized Iterative Sparse Partial Correlation Estimation (Π-SPaCE). This framework does not require prior information: it allows us to estimate the off-diagonal elements of the partial correlation matrix directly, and is faster than traditional methods in the high-dimensional sparse matrix setting. We study this method using simulation and an application to whole-brain graph estimation using data from an fMRI study.

Keywords Sparse Partial Correlation Estimation; Graph Estimation; Network Study; fMRI