

Bayesian Spatial Blind Source Separation via Thresholded Gaussian Processes

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Abstract: Blind source separation (BSS) is the separation of latent source signals from their mixtures, which can be achieved by many methods based with different assumptions, criteria or aims, such as principal components analysis (PCA), singular value decomposition (SVD) and independent component analysis (ICA). However, for neuroimaging data analysis, the most existing BSS methods fail to directly account for the spatial dependence among voxels and do not explicitly model the sparsity of source signals. To address those limitations, we propose a Bayesian nonparametric model for BSS of spatial processes. We assume the observed images as the linear mixtures of multiple sparse and piecewise-smooth latent source processes, for which we construct a new class of prior models by thresholding Gaussian processes. We adopt the von-Mises Fisher distribution as the prior model for mixing coefficients. Under some regularity conditions, we show that the proposed model enjoys large prior support; and we establish the consistency of the posterior distribution with a divergent number of voxels in images. The simulation studies demonstrate that the proposed method outperforms the existing ICA methods for latent brain network separation and brain activation region detection. We apply the proposed method to analysis of the resting-state fMRI data in the Kirby 21 dataset, which shows a very promising recovery of latent brain functional networks.