A comparative study of Variational EM and MCMC inferences for the joint detection-estimation of brain activity in fMRI

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In standard within-subject analyses of event-related fMRI data, two steps are usually performed separately: detection of brain activity and estimation of the hemodynamic response function. Because these two steps are inherently linked, we adopt the so-called region-based Joint Detection-Estimation (JDE) framework [Makni et al, 2008; Vincent et al, 2010] that addresses this joint issue using a multivariate inference for detection and estimation. JDE is built by making use of a regional bilinear generative model of the BOLD response and constraining the parameter estimation by physiological priors using temporal and spatial information in a Markovian model [Ciuciu et al, 2003; Vincent et al, 2010; Risser et al, 2011]. In contrast to previous works that use Markov Chain Monte Carlo (MCMC) techniques to sample the resulting intractable posterior distribution [Vincent et al, 2010], we recast the JDE into a missing data framework and derive a Variational Expectation-Maximization (VEM) algorithm for its inference [Chaari et al, 2011]. A variational approximation is used to approximate the Markovian model in the unsupervised spatially adaptive JDE inference, which allows automatic fine-tuning of spatial regularization parameters. It provides a new algorithm that exhibits interesting properties in terms of estimation error and computational cost compared to the previously used MCMC-based approach [Chaari et al, 2013]. Experiments on artificial and real data show that VEM-JDE is robust to model misspecification and provides computational gain while maintaining good performance in terms of activation detection and hemodynamic shape recovery [Chaari et al, 2013].

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