A Formal Bayesian Approach to SENSE Image Reconstruction Leads to More Statistically Significant Task Activation in fMRI

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Abstract

In fMRI, capturing cognitive temporal dynamics is dependent on how quickly volume brain images are acquired. The sampling time for an array of spatial frequencies to reconstruct an image is the limiting factor in the fMRI process. Multi-coil Sensitivity Encoding (SENSE) image reconstruction is a parallel imaging technique that has greatly reduced image scan time. In SENSE image reconstruction, coil sensitivities are estimated once from *a priori* calibration images and used as fixed "known" coil sensitivities for image reconstruction of every subsequent image. This technique utilizes complex-valued least squares estimation via the normal equation to estimate voxel values for the reconstructed image. This method can encounter difficulty in estimating voxel values if the SENSE design matrix is not positive definite. Here, we propose a Bayesian approach where prior distributions for the unaliased images, coil sensitivities, and uncertainty are assessed from the *a priori* calibration image information. Images and coil sensitivities are jointly estimated *a posteriori* via the Iterated Conditional Modes algorithm and Markov chain Monte Carlo using Gibbs sampling. In addition, variability estimates and hypothesis testing is possible. This Bayesian SENSE (BSENSE) model utilizes prior image information to reconstruct images from the posterior distribution and is applied to simulated fMRI data. This BSENSE model produced a cleaner, less noisy reconstructed image compared to SENSE meaning a clearer distinction between the different brain matter. It also performed better in capturing the increased signal from the task activation and decreased the correlation between aliased voxels over time. This simulated experiment was performed on a single slice non-task image, a series of non-task images, and a series image with task activation mimicking a real fMRI experiment.

Key Words: Bayesian, SENSE, fMRI, reconstruction

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