A Bayesian Spatial Mixture Model for FMRI Analysis

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One common objective of fMRI studies is to identify voxels or points in the brain, which are activated by a neurocognitive task. This is an important multiple comparisons problem, since typically inference (often using z- or t- tests) is performed on each of thousands or hundreds of thousands of voxels. The false discovery rate has been studied for use in this problem by several authors. Finite mixture models have also been proposed to address the multiplicity issue, where voxels are classified according to being activated or not activated by the cognitive task. Links between the false discovery rate and mixture models have been shown in the literature. One limitation to these procedures is that activation is typically expected to occur in clusters of neighboring voxels rather than in isolated single voxels; methods which do not account for this may have lower sensitivity to activation. We propose a Bayesian spatial mixture model to address these issues. Each voxel has an unknown or latent activation status, denoted by a binary activation variable. The spatial model for the binary activation indicators is induced by a latent Gaussian spatial process (a conditional autoregressive, or CAR, model), thresholded to produce the binary activation, analogous to a spatial probit model. An efficient Gibbs sampling algorithm is developed to implement the model, yielding posterior probabilities of activation for each voxel, conditional on the observed data. We apply this method to a real fMRI study, and compare its performance in simulation with other methods proposed for fMRI analysis.