Using Variational Bayesian Expectation Maximization (VBEM) Method for Multi-Area Integrated MEG/fMRI Model

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Integrated analysis of the magnetoencephalography (MEG) and functional MRI (fMRI) gives better results compared to separate analysis. For the integrated analysis, an integrated bottom-up model and a framework to estimate the parameters of the model are required. In this study, we propose a multi-area integrated model and implement a Bayesian approach to estimate its parameters. We extend our previously proposed integrated MEG and fMRI neural mass model to a multi-area model by defining two types of connections: the Short-Range Connections (SRCs) between minicolumns within an area and Long-Range Connections (LRCs) betweens minicolumns of two areas. The nonlinear input/output relationship in the proposed model is derived from the state space representation of the multi-area model. For estimating parameters of the model, we propose the variational Bayesian expectation maximization (VBEM) method which iteratively optimizes a lower bound on the marginal likelihood. Each iteration of the VBEM consists two steps: a variational Bayesian expectation step which is implemented using the extended Kalman filter; a variational Bayesian maximization step where the posterior distributions of the parameters are inferred. For activation detection using proposed method, number and locations of the active areas of the brain is estimated using conventional fMRI analysis and different configurations of connections between the areas is considered to construct several models. Using the proposed VBEM method, the best model is chosen among the possible models and activations in its areas as well as strengths of connections between the areas is estimated. The efficiency of the proposed VBEM method is illustrated using various simulation studies as well as real MEG and fMRI data. This study proposes an effective method to integrate MEG and fMRI and hopes to more effectively use these techniques in functional neuroimaging.