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Abstract Deadline: April 15, 2009

Parameter Estimation of Integrated E/MEG and fMRI Model Based on Variational Bayesian Framework

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Introduction: The integrated analysis of the Electroencephalography (EEG), Magnetoencephalography (MEG), and functional magnetic resonance imaging (fMRI) are instrumental for functional neuroimaging of the brain. A bottom-up integrated E/MEG and fMRI model based on physiology as well as a method for estimating its parameters are keys to the integrated analysis.

Methods: We propose the variational Bayesian expectation maximization (VBEM) method to estimate parameters of our proposed integrated model. VBEM method iteratively optimizes a lower bound on the marginal likelihood. An iteration of the VBEM consists of two steps: a variational Bayesian expectation step implemented using the extended Kalman smoother (EKS) and the posterior probability of the parameters in the previous step, and a variational Bayesian maximization step to estimate the posterior distributions of the parameters. For a given external stimulus, a variety of multi-area models can be considered in which the number of areas and the configuration and strength of connections between the areas are different. The proposed VBEM method can be used to select an optimal model as well as estimate its parameters.

Results: The efficiency of the proposed VBEM method is illustrated using simulation results where the real and estimated parameters were in good agreement. Parameters of the multi-area model are estimated using a MEG dataset collected from an auditory stimulus to evaluate the capability of the proposed multi-area model as well as the proposed VBEM method in a real condition. We demonstrate that the multi-area model can appropriately fit the real data using variations of the short-range connections (SRCs) and long-range connections (LRCs) parameters. Restricting the parameters of the model to the LRCs parameters and fixing the intra-minicolumn and SRCs parameters at their mean values gives acceptable fit of the real data (with less than 10% error).

Conclusions: The proposed VBEM method can be used to estimate parameters of other non-linear dynamical systems. This study proposes an effective method to integrate E/MEG and fMRI and plans to use these techniques in functional neuroimaging.

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