S04-1 (02/15 15:25-15:50)

Fully Bayesian Estimation of Virtual Brain Parameters

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Abstract

Virtual brain models are data-driven patient-specific brain models integrating individual brain imaging data with neural mass modeling in a single computational framework, capable of autonomously generating brain activity and its associated brain imaging signals. Along the example of epilepsy, we develop an efficient and accurate Bayesian methodology estimating the parameters linked to the extent of the epileptogenic zone. State-of-the-art advances in Bayesian inference using Hamiltonian Monte Carlo (HMC) algorithms have remained elusive for large-scale differential-equations based models due to their slow convergence. We propose appropriate priors and a novel reparameterization to facilitate efficient exploration of the posterior distribution in terms of computational time and convergence diagnostics. The methodology is illustrated for in-silico dataset and then, applied to infer the personalized model parameters based on the empirical stereotactic electroencephalography (SEEG) recordings of retrospective patients. This improved methodology may pave the way to render HMC methods sufficiently easy and efficient to use, thus applicable in personalized medicine.

Keywords:
Bayesian Inference; Brain-Network Modelling; Epilepsy; Hamiltonian Monte Carlo; Personalized Medicine.