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Variational Bayesian localization of EEG sources with generalized Gaussian priors

Abstract: Although in the last decades the use of neuroimaging modalities based on Magnetic Resonance Imaging has been massively adopted for the structural analysis of the brain, including MRI, fMRI and recently DTI, several reasons make the Electroencephalography (EEG) still-today an irreplaceable technique for the understanding of brain organization and function. First, its temporal resolution is very fine as it allows for the monitoring of biolectrical activity in the millisecond time-window; second, its interpretability is very straightforward since EEG is a direct measure of brain bioelectrical activity (more precisely, EEG captures the postsynaptic cortical currents generated by large assemblies of pyramidal neurons); and last but not least, it is a non-invasive technique which requires a simple and cheap experimental setup. Although in some situations the EEG fine temporal resolution might suffice for the understanding of some aspects of brain function, the spatial resolution of the EEG is very poor since it is based on a small number of scalp recordings, thus turning the source localization problem into an ill-posed and no unique solution exists for the localization of the neuronal generators. Many methods have been proposed to overcome this localization. We present in this talk a mathematical, pedagogical derivation for some of these methods, and in particular we will focus on the methods that use Bayesian Inference to overcome the ill-posedness of the localization problem by adding prior information to the sources space. The final product is an algorithm that performs simultaneously the estimation of both sources and model parameters. More concrete, our Bayesian approach eliminates the need to hand-tune the model parameters and can be used to localize both smooth and abrupt profiles of electrical activity. Finally, the suggested algorithm is validated on simulated data.