Thesis Proposal

MACHINE LEARNING
DEPARTMENT

Information flow in networks based on nonstationary multivariate neural recordings

Abstract:
Neural recordings, such as local field potentials (LFPs), reflect the activity of populations of neurons in time-varying voltage traces and, due to high temporal resolution, they are well-suited for identifying networks of interacting brain regions. Typical analyses are performed on the average across many repetitions of the same task, which eliminates the variation needed to quantify statistical associations between nonstationary signals. In this thesis, I extend statistical and machine learning methodology from graphical models, time series and spatiotemporal models, and Bayesian hierarchical models to develop new tools appropriate for identifying networks of interacting brain regions from multivariate neural recordings. I discuss three different methods, each designed to focus on different a characterization of association.

First, using computationally efficient kernel dynamic canonical correlation analysis, we identified time-varying lagged correlations between multi-electrode LFPs from two brain regions (Rodu, Klein, et al, J. Neurophys., 2018). Second, in work submitted for publication, we developed a novel undirected graphical model suitable for identifying lagged synchronization of neural oscillations via phase coupling and provided inference methods for graphical structure learning. Finally, my current work seeks to infer neural circuitry during stimulus processing on the finer spatial scale of a laminar LFP recording in one cortical area. In particular, I propose using a biophysically-motivated spatiotemporal Gaussian process model to solve an ill-posed inverse problem to recover the current sources generating the observed voltage traces. In addition, I propose a Bayesian hierarchical model for variation in nonstationary stimulus responses, where correlated current source variation across cortical layers may indicate information flow. I plan to demonstrate these methods in laminar LFP recordings from primary auditory cortex.

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