THE UNIVERSITY OF CHICAGO

Department of Statistics

STATISTICS COLLOQUIUM

CLAIRE DONNAT

Statistics Department
Stanford University

Quantifying Uncertainty in Complex Systems with Applications to Brain Connectomics

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Jones 303, 5747 S. Ellis Avenue

ABSTRACT

From social networks to neurosciences, graphs have rapidly become ubiquitous by offering a versatile modeling framework in which data points are represented as nodes, and various aspects of the underlying organization of the data are captured through edges. Brain Connectomics —— a developing field in cognitive neuroscience —— is a case in point, as it strives to understand cognitive processes and psychiatric diseases through the analysis of interactions between brain regions. However, in the high-dimensional, low-sample, and noisy regimes that typically characterize fMRI data, the recovery of such interactions remains an ongoing challenge: how can we discover robust patterns of co-activity between brain regions that could then be associated to cognitive processes or psychiatric disorders? How can we quantify the uncertainty associated to these discoveries? In this talk, we investigate a constrained Bayesian Independent Component Analyis (ICA) approach which simultaneously allows (a) the fexible integration of multiple sources of information (fMRI, DWI, anatomical, etc.), (b) an automatic and parameter-free selection of the appropriate sparsity level and number of connected submodules and (c) the provision of estimates on the uncertainty of the recovered interactions. Our experiments, both on synthetic and real-life data, validate the flexibility of our method and highlight the benefits of integrating anatomical information for connectome inference.