Frequency dependent causal inference

Background: Causal inference is one of the basic scientific topics with a long history. It's also widely applied in brain science. Due to the tiny and complex structure of cortical network, it's expensive to directly imaging wiring structure of cortical networks. However, measure the activity of neurons, especially with the help of new techs such as multi-electrode array and Neuropixel, is much cheaper and practical. Thus, causal inference answers the question that how can we extract the information of structure connectivity from those measurements of activities. In this project, we mainly use the time-delayed mutual information (TDMI) as the tool (Li et al, 2017) (Li et al, 2018). We want to ask: how does the preprocessing process, such as band filtering, affect the result of inference?

Project setups: We provide the basic framework of causal inference methods to test. [Jupyter Notebook demo]

Project map: The project core is covered by ; subsequent questions can be taken in any order.

Q1. Build a two-node or three-node Gaussian regression model. Compute the TDMI between time series of nodes. Can it reconstruct the physical connections?

Q2. Filter the raw time series into different frequency bands. Again operate TDMI analysis on the filtered signals. Does it still works for all bands?

Q3. What does the frequency dependent causality relay on? The interaction, or the time constant of the system itself?

Q4. Build an SNN model with hundreds of thousands of neurons. Use the point source approximation to model the local field potential (LFP) of subpopulations.

Q5. Apply TDMI analysis on LFPs. Can it reconstruct the effective connections between subpopulations? Search for dynamical regime that TDMI analysis works.

Q6. Can you theoretically build the quantitative relation between TDMI and physical connectivity?