Using a Network Modeling Environment to Evaluate Statistical Methods of Identifying Network Structure

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Motivation

Validate and develop statistical methods in neuroscience.

- Recent advances in network modelling provide a framework for controlling the generation of spiking data.
- Statistical methods of evaluating network structure can thus be validated, and new methods developed.

Goals and Methods

Modify LIF to get at true firing rate. Create interesting network.

- Using NENGO, a large scale neural simulation package, networks with complex and interesting dynamics can be generated.
- NENGO allows access to and modification of input to the network through any node and connections between nodes.
- A modification of normal spiking LIF neurons, probabilistic LIF (p-LIF), is used to get accurate instantaneous firing rates (iFRs) of individual neurons.
- p-LIF neurons have probability of firing governed by their voltage as follows:

\[ P(\text{firing} \mid v) = \frac{e^{K_1 v + b}}{1 + e^{K_1 v + b}} \]

- The parameters of this distribution are adjusted to fit the behavior of normal LIF neurons.

p-LIF Results

pLIF neurons fit the PSTH of LIF neurons well given stochastic input. ISI distributions are more difficult to match.

- p-LIF neurons matches LIF behavior well, as measured by MSE between PSTH bins and the KS-statistic between each neuron model distribution of inter-spike intervals, over 100 trials.
- Neurons are stimulated with spikes generated from an inhomogeneous Poisson process, itself modelling the input of various proportions of spiking excitatory and inhibitory neurons.
- Threshold of normal LIF neurons is defined as \( t \). Inputs and the firing distribution of p-LIF neurons are scaled accordingly.

Current Steps

Fit iFR and compare to actual. Develop and test a full network.

- Fit iFR with a Poisson regression with spline basis elements on time and time since last spike.

\[ \log(\lambda(t, t - s_i(t))) = \log(\lambda_1 + \log(\lambda_2(t - s_i(t))) \]

- Set connections between p-LIF neurons that produce interesting network dynamics.
- Evaluate statistical methods for the identification of network structure.

Conclusion

ISIs are potentially a problem. Must compare estimated iFR to true iFR.

- Though the p-LIF PSTH visually matches that of the normal LIF well for even low parameter values, the KS test is not significant.
- The p-LIF has a different distribution of ISIs from the LIF due to the probabilistic nature of spiking - it will spike around the same time the LIF will spike, but with some variation.
- This is the cause of the non-significant KS test for low values.

References:


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