CNS Assignment: Inhibitory-Stabilized Networks

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1 Introduction

Introduce ISN - explain the model and its components

Inhibitory neurons maintain the network activity in a balanced regime, preventing endless excitation, preventing the network from being functional and balanced. This is achieved by the inhibitory neurons being activated by the excitatory neurons, to which they are connected via synapses. The ISN neurons can be described by the following 2 equations:

$$\tau_E \frac{dV_E}{dt} = -(V_E - V_{\text{rest}}) + W_{EE}\varphi(V_E) - W_{EI}\varphi(V_I) + u_E \tag{1}$$

$$\tau_I \frac{dV_I}{dt} = -(V_I - V_{\text{rest}}) + W_{IE}\varphi(V_E) - W_{II}\varphi(V_I) + u_I \tag{2}$$

They describe Excitatory (E) and Inhibitory (I) neuron behaviour. To understand how the 2 come together, it is important to understand the underlying model of a nueron and how the interaction is introduced.

1.1 Leaky Integrate-and-Fire Neuron

{equation}

Breakdown: 1. change in membrane potential is modelled as an ODE 2. Tau - time for a signal to fully be absorbed 3. Resting potential 4. Conductance 5. External current

External current is the component of interest - it allows to establish a communcation channel between the nuerons - the **total** synaptic current of the adjacent neurons is the external input to each indivudual neuron.

{equations for modelling synaptic current }

1.2 Considerations

1. The model keeps the key mechanisms of a real neural network - oscillations, reaction to external input, delayed reaction, inter-neural interactions

2. While capturing important features, the model abstracts away the full detail of chemical & biological structure of the cells and the medium around them

to spare the complexity in order to make the model cheaper computationally and more tractable analytically.

2. The "transfer function" is linear, whereas in reality it is driven by a stochastically opening and closing ion-channels, which would have a different shape

3. The model is a lot more computationally affordable - we can run large scale simulations on 1 ODE per Neuron, instead of 4 as it is with the biologically more plausible Hodgkin-Huxley model

4. Simpler model also is more amenable to theoretic analysis - helps to understand network stability, activity patterns and interpret them.

2 Problem 1

3 Problem 2

4 Problem 3