SYDE552/BIOL 487 Assignment: Spatiotemporal Receptive Fields and Models of Spiking

25 marks total
Due April 1

Submit the following:

- A PDF with the requested figures and brief explanations.
- Your Matlab or Python code

Part One: Spatiotemporal Receptive Fields

1. Describe the spatiotemporal receptive fields of V1 simple cells (~200 words).
2. Read Nishimoto, S., Vu, A. T., Naselaris, T., Benjamini, Y., Yu, B., & Gallant, J. L. (2011). Reconstructing visual experiences from brain activity evoked by natural movies. Current Biology : CB, 21(19), 1641–6. Explain their methods in terms of spatiotemporal receptive fields (~500 words).

Part Two: Spiking

1. Nernst Potential
    a. Plot the Nernst potential of Na^+ channels vs. external concentrations $[Na^+]_{out}$ of 1-200mM/l , with a constant internal concentration of $[Na^+]_{in}$=10mM/l.
2. Simulate an adapting leaky-integrate-and-fire spiking model for 1/2s, with a fixed time step of 1/2ms. Plot the subthreshold membrane potential and adaptation conductance. Use the following parameters:
    - electrode current: 1.1e-9A
    - specific membrane capacitance: 10e-9F/mm^2
    - specific membrane resistance: 1e6ohms mm^2
    - post-spike refractory time: .002s
    - adaptation conductance time constant: .1s
    - adaptation conductance spike increment: 1e-9S
    - Leak equilibrium potential: -.065V
    - K+ equilibrium potential: -.075V
    - membrane area: .1mm^2
    - spike threshold potential: -.055V
    - post-spike reset potential: -.070V
3. Izhikevich Model
    a. Simulate a regular-spiking Izhikevich neuron for 500ms of simulation time, time step 0.2ms, using the parameters from Izhikevich (2003) IEEE Trans Neural Networks. Set I=0 for 0-100ms and I=10 thereafter. Note that the equations are in terms of mV and ms. Plot u vs. v, along with the u and v nullclines, with both I=0 and I=10 (find these by setting the derivatives of u and v to zero). Make another such plot for a fast-spiking neuron.