Principles of Brain Computation

SS 2018

HW 1: The Leaky Integrate-and-Fire Model

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The leaky integrate-and-fire model (LIF)

- One the simplest neuron models
- Derived from electrical properties of cell membrane

Electrical properties of neurons

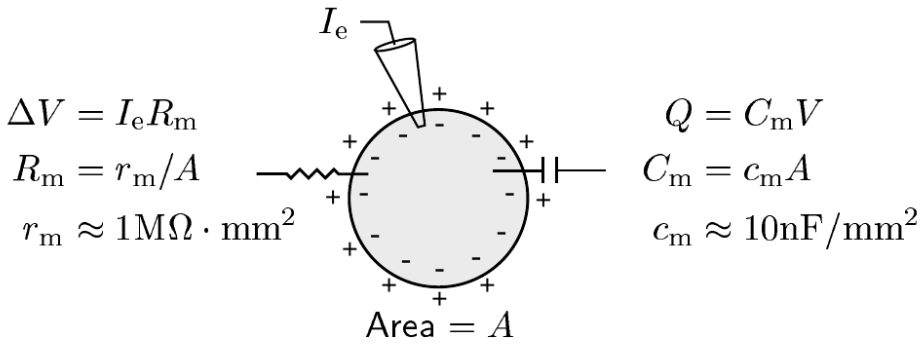

Figure 5.3: The capacitance and membrane resistance of a neuron considered as a single compartment. The membrane capacitance determines how the membrane potential V and excess internal charge Q are related. The membrane resistance R_m determines the size of the membrane potential deviation ΔV caused by a small current I_e entering through an electrode, for example. Equations relating the total membrane capacitance and resistance, C_m and R_m, to the specific membrane capacitance and resistance, c_m and r_m, are given along with typical values of c_m and r_m. The value of r_m may vary considerably under different conditions and for different neurons.

Dayan, Peter, and Laurence F. Abbott. Theoretical neuroscience. Vol. 806. Cambridge, MA: MIT Press, 2001.

The leaky integrate-and-fire model (LIF)

Create equivalent circuit and find equation describing $u(t)$?

Response of neurons to injected current

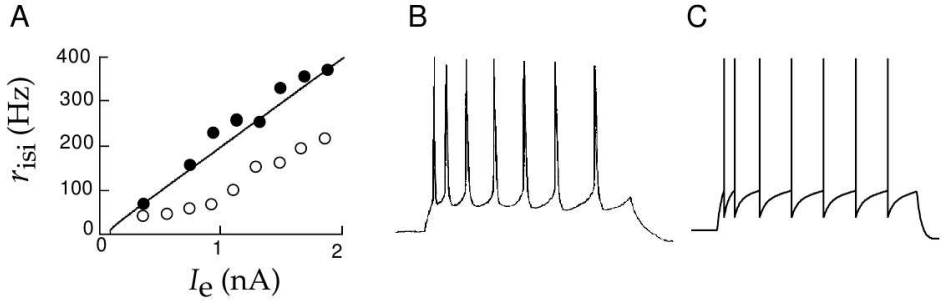

Figure 5.6: A) Comparison of interspike-interval firing rates as a function of injected current for an integrate-and-fire model and a cortical neuron measure *in vivo*. The line gives r_{isi} for a model neuron with $\tau_{\text{m}} = 30$ ms, $E_{\text{L}} = V_{\text{reset}} = -65$ mV, $V_{\text{th}} = -50$ mV and $R_{\text{m}} = 90$ MΩ. The data points are from a pyramidal cell in the primary visual cortex of a cat. The filled circles show the inverse of the interspike interval for the first two spikes fired, while the open circles show the steady-state interspike-interval firing rate after spike-rate adaptation. B) A recording of the firing of a cortical neuron under constant current injection showing spike-rate adaptation. C) Membrane voltage trajectory and spikes for an integrate-and-fire model with an added current with $r_{\text{m}}\Delta g_{\text{sra}} = 0.06$, $\tau_{\text{sra}} = 100$ ms, and $E_{\text{K}} = -70$ mV (see equations 5.13 and 5.14). (Data in A from Ahmed et al., 1998, B from McCormick, 1990.)

Dayan, Peter, and Laurence F. Abbott. Theoretical neuroscience. Vol. 806. Cambridge, MA: MIT Press, 2001.