

Problem Set 4

Quan Wen

Due next Monday: 30 September 2024

Shunting Inhibition on membrane potential and firing rate

Recall that the effect of shunting inhibition on membrane potential is divisive by changing membrane conductance. Using the Integrated-and-fire model we discuss in the class and homework and show that its effect on firing rate is instead subtractive.

Wiring optimization and the presence of axons, dendrites and spines

The design III discussed in the class involves both axons and dendrites. I also argue that the wiring length can be further reduced by the presence of spine. Spine has a typical length of $2\mu\text{m}$. However, it has a very narrow neck, and its volume is much smaller than a dendrite with the same length. Show that in this case, the linear size of the neural network becomes

$$R \sim N^{2/3} d^{4/3} / s^{1/3} \quad (1)$$

and the total wire length of a neuron is given by

$$l \sim N \frac{d^2}{s} \quad (2)$$