Computational Neuroscience: Problem set 6

Neural Networks

Spiking network

Step 1. Read the code SpikingNetwork.m, where a network of excitatory and inhibitory spiking neurons is implemented. However the integrate-and-fire model is missing. Insert your neuron model (coded in the problem set 4) into the code SpikingNetwork.m (the line missing is clearly noted). Run the network and observe what is plotted. Comment.

Step 2. Change the mean current to the neurons from $Nmean = 0$ to $Nmean = 0.5$, run the network. Comment.

Step 3. Go back to the mean current $Nmean = 0$. Change the amplitude of the noise from $Nsig = 1.0$ to $Nsig = 0.5$, run the network. Comment

Step 4. Set the mean current $Nmean = 0.75$. Change the amplitude of the noise to $Nsig = 0.25$. Now explore how sensitive the network is to a small perturbation, such as an extra spike. Do this by forcing a neuron (or a few neurons) of your choice to spike after 200 timesteps, and running the network for a further 100 timesteps. Compare the spiking output of this network with the exact same network, but where the extra spike is not inserted. This can be done by plotting the raster plot of both network runs on the same figure, with different colours. Comment.

Hint 1: you can force a neuron to spike by setting its voltage to the spiking threshold.
Hint 2: To compare the exact same network, you will have to use the same seed for the random number generator as you run the network with and without the extra spike. You can do by inserting the line of code ′ rng(100); ′ at the beginning of your simulation. The number inside the bracket is the seed, so here we have used a seed of 100.

Step 5. Plot the incoming synaptic current over time of an example neuron in the network. In order to do this you will have to save the incoming synaptic current (the vector Ichem in the code) of a neuron each timestep, and plot the result.

Now we will vary the size of the network. Run the network over a large range of size (e.g. 500,5000,50000,500000). The simulations will take longer as you increase the size. Plot the incoming synaptic current of an example neuron from each network as you vary the size. Comment. Note that the synaptic weight, W, scales with $1/N$.

Now change the synaptic weight W so that it scales with $\sqrt{1/N}$, by setting $W = 2/\sqrt{N}$. Run the network over a large range of sizes again, and plot the synaptic currents for each network size. Comment.