Assignment 2: Propagation of Information in Spiking Networks

Neural Computation 2018/19

7th November 2018

Practical info

Due: 4pm Thursday 29 November, 2018

We may not be able to provide full feedback on assignments submitted after this date.

Organize your answers according to the questions; don't merge them. Plots should include axis labels and units. Some answers may require units as well. You will find that some questions are quite open-ended. In order to receive full marks for those you will need to do more than running a simulation and making a plot. Instead, you should justify your choices, and substantiate your explanations and claims, for instance by doing additional simulations or mathematical analysis. Just writing down all you can think of is discouraged, and incorrect claims can reduce marks. It should not be necessary to consult scientific literature, but if you do use additional literature, cite it. Add your code as an appendix to allow the marker identify problems, but note this can not replace an answer to a question. We will examine code as far as possible, but will be unlikely to trace back every bug.

For policies on late submissions, see the School Late coursework & extension website:

`https://bit.ly/1Jy2YyV`

Please note that the University has very strict guidelines on plagiarism, which apply for all marked coursework. You should not copy results, code or text from others. For information, please consult the School Academic misconduct website:

`https://bit.ly/2PTUH3A`

Submit using the submit system: `http://computing.help.inf.ed.ac.uk/submit`

Model and setup

Neurons in the cortex have been described to be bombarded with background synaptic inputs at all times. The role of this background activity is not clear, but it is often suggested that it maybe crucial for how the brain computes. In this assignment, we are interested in studying how background noise may influence how networks of spiking neurons respond to transient stimulus input and propagate their activity across cortical layers

In this assignment we study the response of a population of 1000 integrate and fire neurons. We are interested in how this population reacts when the input changes. You can use the script of the practical on the website as a basis, with parameters: $V_{rest} = -70mV$, $V_{thr} = -50mV$, $V_{reset} = -70mV$, $\tau_m = 50ms$, $dt = 0.1ms$, $R_m = 1$.

Simulate the network for 400ms. For the first 200ms, all neurons receive a small background current with a certain mean and independent Gaussian noise. The next 200 ms a strong stimulus is presented (with the same noise), firing the neurons at some 50-100Hz. To analyze the population response plot the PSTH (averaged over the population) with 2ms time bins.

Questions

Question 1 (20 marks) Examine how 1) the background stimulus strength, and 2) the standard deviation of the noise influence the response of the population when the stong stimulus is presented. Explain the findings. (No fully extensive parameter sweeps needed).

Question 2 (40 marks) What would happen if multiple populations from the previous question were chained in successive layers? Try to illustrate this using a simulation, you can take 5 layers each with $N = 20$, the first layer should recieve input from a stimulus (as in Q1) and the rest only recieve input through uniform connections from previous layers. You will need to use a sufficiently high gain W between layers.

Question 3 (40 marks) Next, replace the background and stimulus current with synaptic input currents driven by a Poisson process. To do this you will need to set background and stimulus event rates r_{bg}, r_{stim} and define a current amplitude I_{Syn0}. Make sure this value is set suffieciently high such that spikes are generated ($I_{Syn0} = 100$, $r_{bg} = 0.01$, $r_{stim} = 0.1$ should be a good starting point to explore). The synaptic events should decay exponentially with a time constant $\tau_{syn} = 5ms$.

State how you implemented the Poisson input and verify that it has the desired properties. How can you get the high and low noise regimes from Question 1?