

CN510 Assignment 9: Correlated Inputs in Spiking Network

Due Thursday Nov 21, 2013

The purpose of this assignment is to set the network architecture for learning in the spiking network. It relies heavily on your previous work in assignments 6 and 8. All parameters that are not explicitly set here remain the same as in these assignments.

Correlated Poisson input

Generate 10 independent Poisson spike trains with rate $\nu = 5Hz$ the same way you did in assignment 6. Now apply some Gaussian jitter to each spike. Take the normal distribution with the $\sigma = 3ms$ and apply it to each spike in each of the 10 traces. This will result in 10 new spike traces that are similar but not identical to the original traces. Repeat this procedure 8 more times, so that you have your original set of 10 traces plus nine jittered sets of 10 traces each. Similar to assignment 6 set the end of simulation time T at the time when the shortest trace emits the last spike (minimal of last elements of all s_i) plus 50 ms (cut off the longer traces).

Adjust the above traces in such a way that spike timings align with 1ms resolution grid the same way you did in assignment 6. Note that you shall apply jitter first and round the values after that.

Create a rastergram plot of all spikes against time where each spike of a certain cell is represented as a dot in a row corresponding to this cell. Order the traces by groups of 10 versions of each original trace to better see similarity. Here the individual spikes do not matter that much, but the overall input activity is, the resulting dots shall show some correlations between different cells unlike your plots from assignment 6.

Synaptic Traces

Use your code from assignment 6 (use any value of C you prefer) to plot new synaptic traces. Plot the two traces. Provide a zoom in on the plot for times between 1000 and 2000 ms.

Add all traces together or use Rotter-Diessmann cumulative trace to get the total synaptic input x_{cum} through time and plot it. Provide a zoom in on the plot for times between 1000 and 2000 ms. Use equations (3) or (4) from assignment 8 for the trace and 2000 random initial weights $w_i(0)$ uniformly distributed between 0 and 1 to establish all to all connectivity between 100 input spike trains and 20 postsynaptic cells.

Postsynaptic Cells

For postsynaptic cells we will add some complications comparing to assignment 6. Firstly, use a population of 20 cells all governed by equation

$$V_i(n+1) = V_i(n)e^{-D(t_i(n+1)-t_i(n))} + \left(x_i^{cum}(n) - \sum_{j \neq i} y_j(n) \right) \frac{\tau_s \tau_m}{\tau_m - \tau_s} \left(e^{-D(t_i(n+1)-t_i(n))} - e^{-A(t_i(n+1)-t_i(n))} \right) \quad (1)$$

Secondly, use the same spiking threshold and voltage reset as in assignment 8, compute the postsynaptic trace y_i using equation (6) in assignment 8

$$y(n+1) = y(n)e^{-A(t_i(n+1)-t_i(n))} + q(n+1)(B - Cy(n)) \quad (2)$$

and plug it in the equation (1) above. This will provide us a very crude approximation of inhibitory horizontal connectivity among postsynaptic cells (we follow Grossberg 1976 here so all other cells inhibit the cell i). For extra credit you can make this inhibition faster than linear by squaring $y_j(n)$.

Compute the membrane potential and plot it for two of the cells. Provide a zoom in on the plot for times between 1000 and 2000 ms. If possible, pick the two cells that clearly respond to different input combinations. You might want to regenerate the weights a few times so that you get the best variety of postsynaptic responses. If so, then save these best initial weights somewhere, you will need them in the next assignment for better results.

Grading Rubric:

25 points **Correlated input traces** of which

10 points Well-formatted plot

15 points Correctness of results

75 points **Postsynaptic voltage traces** of which

10 points Well-formatted plots

30 points Correctness of results

35 points Discussion of results with comparison to cells without recurrent inhibition from assignments 6 and 8