MATH 4803 Computational Neuroscience (Fall 2024)
Problem set 4

DUE at 11:59 pm Tuesday, October29

Submit electronically via Canvas by uploading a file. You are welcome to work together, but should submit your own work. You can utilize needed parts of the code posted on Canvas.

1. Consider two neurons that respond independently of each other. Let r_1 and r_2 denote the firing rates of these two neurons, respectively. Show analytically that the entropy $S(r_1, r_2)$ of the joint firing rates is equal to $S(r_1) + S(r_2)$. Why should the neuronal responses be independent of each other for the additivity to hold?

2. Show analytically that for a spike train that follows a Poisson distribution the probability density for an inter-spike interval of δt is given by

$$P(\delta t) = re^{-r\delta t}$$

i.e., given a spike at t_j the probability that the next spike occurs within the interval $[t_j + \delta t, t_j + \delta t + \Delta t]$ is given by $P(\delta t)\Delta t$.

3. We will simulate spikes generated by a homogeneous Poisson process and a modification of the Poisson process with an absolute refractory period.

   (a) Generate 1000 realizations of a Poisson process with rate $r = 10$ (Hz) over the time interval of duration $T = 10$ (s). Compute the fano factor from the mean and the variance of spike counts. Then, record the interspike intervals and plot a histogram of the interspike interval. Show whether it is exponentially decaying by plotting them on the log-y scale. Are your results consistent with the predictions for a Poisson process?

   (b) Now, do the same as in part (a), but with an absolute refractory period of 5 (ms). Comment on the fano factor of the spike count distribution and the histogram of the interspike-interval distribution.

   (c) Submit your code.