Problem set 8

Analysis for Neuroscientists

October 31, 2022

1. The file `kcs.mat` contains a matrix `J` of synaptic connections from projection neurons to Kenyon cells obtained through electron microscopy [1]. Each row is a Kenyon cell and each column is a projection neuron. `J` is 1 if a connection is present and 0 if not.

   (a) What is the average probability of a connection over this whole matrix?

   (b) Create a vector of number of connections per Kenyon cell with `conns = sum(J,2)`. Now, create a vector `cdf_conns`, of length 11, containing the fraction of Kenyon cells that have less than or equal to `k` connections, for $k = 0, 1, 2, \ldots 10$. This vector represents the *cumulative distribution function* (cdf) of the number of connections per Kenyon cell. Plot the cdf as a function of k.

   (c) On the same plot, plot the cdf of a binomially distributed random variable with the probability you calculated in (a) and the number of projection neurons (number of columns in `J`). You can use the function `binocdf(k,N,p)`. Is a binomial distribution a good model of this data?

2. Load the dataset `trace.mat`, which contains data from the MICrONS project. In this file are two variables. The first is `trace`, a 27100 $\times$ 35 data matrix of calcium imaging data from 35 simultaneously recorded cells from mouse visual cortex. The second is `stim`, which is a length 27100 vector representing the orientation of the currently presented stimulus (-1 when no stimulus is being presented). We won't be using the `stim` variable for these questions.

   (a) Make a plot of the covariance matrix of this data using `cov`. Then, make a plot of the matrix of correlation coefficients using `corrcoef`.

   (b) Now, z-score the data and replot the two matrices from (a). Comment on the difference between what you see after z-scoring.

   (c) If we record from N neurons, how many distinct pairs of neurons are there? Write a function that takes a covariance matrix and returns a vector of the length you just calculated, containing only the entries of that matrix corresponding to these distinct pairs. Plot a histogram of the values of the correlation coefficients for these pairs.

References

[1] Eichler, K., et al. The complete connectome of a learning and memory centre in an insect brain. *Nature* **548**, 175–182 (2017).