Problem Set 6 -- Introduction to data analysis

Computational Neuroscience Summer Program

June, 2011

These questions use two Matlab files:

`http://www.neurotheory.columbia.edu/~larry/book/exercises/c1/data/c1p8.mat`

`http://www.neurotheory.columbia.edu/~larry/book/exercises/c1/data/c2p3.mat`

These questions were adapted from Dayan & Abbott, who in turn took inspiration from Sebastian Seung.

1. Reverse correlation

Load `c1p8.mat`. These data were collected for 20 minutes at a sampling rate of 500 Hz. In the file, rho is a vector that gives the sequence of spiking events or nonevents at the sampled times (every 2 ms). When an element of rho is one, this indicates the presence of a spike at the corresponding time, whereas a zero value indicates no spike. The variable stim gives the sequence of stimulus values at the sampled times. Calculate and plot the spike-triggered average from these data over the range from 0 to 300 ms (i.e, 150 time steps). How do you explain the shape of this curve for values of $t > 0$?

2. Challenge problem: Two-spike reverse correlation

Again using `c1p8.mat`, calculate and plot stimulus averages triggered on events consisting of a pair of spikes (which need not necessarily be adjacent) separated by a given interval. Plot these two-spike-triggered average stimuli for various separation intervals ranging from 2 to 1 0 0 ms. (Hint: you can use convolution for pattern matching: e.g., `find(conv(rho,[1 0 1])==2)` will contain the indices of all the events with two spikes separated by 4 ms.) Plot, as a function of the separation between the two spikes, the sum of the magnitudes of the differences between the two-spike-triggered average and the sum of two single-spike-triggered averages (obtained in exercise 1) separated by the same time interval. At what temporal separation does this difference become negligibly small?

3. Two-dimensional reverse correlation.

Load `c2p3.mat`. This file contains the responses of a cat LGN cell to two-dimensional visual images (these data are described in Kara et al., 2000). In the file, `counts` is a vector containing the number of spikes in each 15.6-ms bin, and `stim` contains the 32767, 16 x 16 images that were presented at the corresponding times. Specifically, `stim(x,y,t)` is the stimulus presented at the coordinate `(x,y)` at time-step `t`. Note that stim is an `int8` array that must be converted into a `double` using the matlab command `stim=double(stim)` in order to be manipulated within Matlab. Calculate the spike-triggered average images for each of the 12 time steps before each spike and show them all (using `imagesc` and `subplot`). Note that in this example, the time bins can contain more than one spike, so the spike-triggered average must be

computed by weighting each stimulus by the number of spikes in the corresponding time bin, rather than weighting it by either 1 or 0 depending on whether a spike is present or not. (Tip: Make the plots look even cleaner by using the same color scale limits for all plots (search '`clim`').) In the averaged images, you should see a central receptive field that reverses sign over time. Also, by summing up the images across one spatial dimension, produce a figure like the one below that plots the response as a function of time (τ) and one spatial dimension (x).