Problem Set 1

1. ***Basic spike train statistics*** – use data from Lab 1 (nsa2009_1.mat)

    a. What is the average firing rate for neuron #33 (in Hz)?

    b. Using bootstrapping over trials – What is the standard error?

    c. The firing rate appears to decrease across trials. How different are the rates on trials 1-75 compared to trials 76-150?

    d. Is the difference statistically significant?

    e. Is the firing of neuron #33 under- or over-dispersed? How can you tell?

2. ***Fitting tuning curves*** – use data from Lab 3 (data_v1_binned_moving.mat)

    a. In Lab 3 we fit a standard von Mises tuning curve model to these data, but a more common model for V1 neurons assumes that the tuning curve is a circular Gaussian:

$$R_{cgs}(\theta; f, b, a, \mu, \sigma, P) = b + a \sum_{k=-\infty}^{\infty} \exp\left\{ -\frac{(\theta f + kP - \mu)^2}{2\sigma^2} \right\}$$

    Plot a circular Gaussian with $\theta=[0,2\pi]$, b=1, a=1, f=2, $P=2\pi$, $\mu=0$, $\sigma=1$. k only needs to go between -4 and 4 for the curve to be accurate. On the same plot add curves with $\sigma=0.5$ and $\sigma=1.5$.

    b. Assuming Gaussian noise, fit this model to the spike counts from dataset 1, neurons 1 and 28.

    c. Is the circular Gaussian model better than the von Mises model for these neurons? How can you tell?

3. ***Visualizing multi-channel EEG*** – use (new) data from Lab 4 (chb_sample.mat)

    a. In Lab 1 we plotted spike rasters with multiple trials from a single neuron aligned to stimulus onset. A common visualization tool is to plot data from multiple electrodes/channels the same way (http://physionet.org/physiobank/charts/chbmit.png). Make such a multi-electrode plot for the first 10 seconds of EEG data. Keep in mind that the sampling rate is 256Hz.

    b. EEG/LFP signal are often highly correlated. Using `corrcoef`, compute correlations between electrodes for this data. Use `imagesc` to visualize the correlation matrix. Does the fact that these are bipolar measurements (http://www.bem.fi/book/13/13.htm#03) affect the correlations?

    c. Somewhere in this data the subject had a seizure. What's the approximate start time? How can you tell?