BE 521: Homework 1

Exploring Neural Signals

Spring 2015

30 points

Due: Tuesday 1/27/2015 11:59 PM

Objective: Working with the IEEG Portal to explore different Neural signals

Homework Policy

1. Piazza should be used for peer discussion for all questions related to course material. Please also use Piazza to contact teaching staff for all questions. TA's will be available to help during office hours and occasionally on Piazza.
2. Submit LaTeX write-up (pdf) and Matlab code to Canvas as pennkey_hwx.pdf, .m before listed deadline.
3. Assignments will be returned electronically on Canvas.
4. Collaboration is encouraged but individual write-ups are required. Please list any collaborators. Honor code will be strictly enforced. Note: submitted code is routinely passed through a plagiarism checker.
5. Late Policy: 5% per day. **No homework is accepted after the 5th late day.** (If originally due Tuesday, 11:59PM, last day to turn in is Sunday, 11:59 PM).

1 Seizure Activity (13 pts)

The dataset `I521_A0001_D002` contains an example of human intracranial EEG (iEEG) data displaying seizure activity. It is recorded from a single channel (2 electrode contacts) implanted in the hippocampus of a patient with temporal lobe epilepsy being evaluated for surgery. In these patients, brain tissue where seizures are seen is oftne resected. You will do multiple comparisons with this iEEG data and the unit activity that you worked with in Homework 0 (`I521_A0001_D001`). You will have to refer to that homework and/or dataset for these questions.

1. Retrieve the dataset in MATLAB using the IEEGToolbox and generate a *session* variable as before (No need to report the output this time). What is the sampling rate of this data? What is the strict upper bound frequency of the signal we can resolve? (2 pts)
2. How does the time scale of this sample compare with the units data in `I521_A0001_D001`? How does the voltage scale differ? (2 pts)

3. Using the time-series visualization functionality of the IEEG Portal, provide a screenshot of the first 500 ms of seizure data. (2 pts)

4. What two main differences do you notice about this 1 second section and the 1 second section of the unit activity from Homework 0, Q1.1? Remember to adjust the gain to the same scale if you are viewing online. (2 pts)

5. The unit activity sample in the previous homework was bandpass filtered between 300 and 3000 Hz. Assume that the seizure activity sample has no such bandpass preprocessing. Assume that the power of a given frequency band for this signal scales roughly as $1/f$ (where f is the frequency of the band).

   How might these differences in preprocessing explain the differences you noted in the previous question? (There is no need to get into specific calculations here. We just want general ideas.) (5 pts)

2 Evoked Potentials (17 pts)

The data in `I521_A0001_D003` contains an example of a very common type of experiment and neuronal signal, the evoked potential (EP). The data show the response of the whisker barrel cortex region of rat brain to an air puff stimulation of the whiskers. The `stim` channel shows the stimulation pattern, where the falling edge of the stimulus indicates the start of the air puff, and the rising edge indicates the end. The `ep` channel shows the corresponding evoked potential.

Once again, play around with the data on the IEEG Portal, in particular paying attention to the effects of stimulation on EPs. You should observe the data with window widths of 60 secs as well as 1 sec. Again, be sure to explore the signal gain to get a more accurate picture. Finally, get a sense for how long the trials are (a constant duration) and how long the entire set of stimuli and responses are.

1. Based on your observations, should we use all of the data or omit some of it? (There's no right answer, here, just make your case either way in a few sentences.) (2 pts)

2. Retrieve the `ep` and `stim` channel data in MATLAB. Based on your decision from Q2.1, compute the average time (in ms) of the peak response after the onset of the stimulus over all the trials? (3 pts)

3. We often want to get a sense for how variable the signal is at a given point in the response. A simple (and simplistic) way to do this is to use a technique known as *signal averaging* to increase the strength of the evoked signal relative to background. Plot the signal averaged (mean) EP with standard deviation errorbars (i.e. each time-point of the time averaged signal will have an error bar). Do this, plotting the mean EP in red and the standard deviation errorbars in gray (RGB value: [0.7 0.7 0.7]). Use the commands `hold on` and `hold off` as well as `errorbar` and `plot`. Make sure to give a proper legend along with your labels. (4 pts)

4. (a) We often want to get a sense for the amplitude of the noise in a signal. Propose a method to do this (there are a few reasonably simple methods, so no need to get too complicated). N.B., do not assume that the signal averaged EP is the "true" signal and just subtract it from that of each trial. Whatever method you propose should be able to work on the signal from a single trial or from the average of the trials. (4 pts)

(b) Show with a few of the EPs (plots and/or otherwise) that this method gives reasonable results. (1 pt)

(c) i. Apply your method on each individual trial and report the mean noise across all trials. (1 pt)

ii. Apply your method on the signal averaged EP and report its noise. (1 pt)

iii. Do these two values make sense? Explain. (1 pt)