MATLAB Assignment #6

For the previous homework you clustered and discriminated spikes using PCA to examine their waveforms and their coefficient map space. You examined these further using autocorrelalograms. In this homework, we will examine the lower frequencies of the recorded electrophysiological data. Spectrograms are often used to look at the energy envelop over different frequency bands as a function of time. A checklist is included at the end of the problem set indicating the items that will be graded. Remember to save your work as you proceed (use the save command). You can explore provided functions by using the help, type or edit commands. Accompanying questions are included at the end of each part to tie the algorithms with the neurophysiological information they intend to capture. As a guideline, answers to each question should consist of 1 to 5 sentences depending on their complexity.

Part III: Field potential power spectrum and spectrogram

For this part, you can start with a new workspace and start as done for Part I (Assignment 4) by loading the original Wideband data, selecting a channel, and plotting it.

20. Filter the widedata to investigate the changes in local field potential. Use a band-pass Butterworth filter of your choosing. You can use the butter and filter commands as before. Justify your filter selection, order and cut-off frequencies. Plot the data using appropriate x and y axis.

21. Check your filter by plotting the power of the filter's frequency response to a white noise input (2-sec in duration). Note that this would be similar to recording electrophysiological data from saline in a beaker. The spectrum might be noisy for a single noise realization, you might need to generate multiple noise realizations (e.g. 20) and averaging the power spectrum. Alternatively, you can divide by the power spectrum of the input signal, use either of these two methods. Make sure you use appropriate x and y axis. You can achieve this using the following pseudo-code.

```
n=randn(2*samprate,20);
for m=1:20,
  y=filter(b,a,n(:,m));
  yf=fft(y);
  y_psd(:,m)=abs(yf.*yf);     % normalize?
end;
x=[0:length(n)-1]*samprate/length(n);     % matching frequency axis
```

Questions to consider:

- How many frequencies did the Fourier transform decompose each 2 second interval into?
- Why is the result symmetric? What is special about the symmetric point?

Is there any significance to the power at 0 Hz? (hint: try subtracting the mean from each trial and recomputing the fft)

22. Re-organize the data into the different stimulation trials as done for Assignment 4. Calculate the PSD for each trial and plot the PSD from one trial. Plot the average PSD from all trials and compare it to one from a single trial (no average). Any differences?

23. Compute the spectrogram of the entire filtered data stream over 0.5 or 1.0 sec windows every 0.1 sec. Plot the resulting spectrogram, make sure you use appropriate axis. You can achieve this using the following pseudo-code, where ii is the number of samples to move each window and i_spectro is the number of samples in a window.

```
ii=floor(length(data)/spectro_df*samprate));
i_spectro=floor(window_dt*samprate);
t_spectro=[1:ii:length(data)]*(spectro_dt/length(data));
f_spectro=[0:i_spectro-1]*(samprate/i_spectro);
for m=1:length(t_spectro),
   tmpdata=data((m-1)*ii+[1:i_spectro]);
   yf=fft(tmpdata);
   spectro(:,m)=abs(yf.*yf);          % normalize?
end;

% to plot the spectrogram use this commands
clf,
pcolor(t_spectro,f_spectro,spectro),      % might need spectro' instead of spectro
view(2), shading('interp'),
axis('tight'),
```

24. Compute the spectrogram of each stimulation trial over 0.5 or 1.0 sec windows every 0.1 sec and average them to obtain the average spectrogram of stimulation. Is visual evoked activity observable?

Accompanying questions:

25. How do synaptic and action potentials differ between intra-cellular recordings and extra-cellular recordings? Can you use the same electrode for both recordings?
26. How can spectrograms help us identify neuronal activity periods? What kinds of activity is it informing us about?
27. How can we use spectrogram data to examine fluctuations that are slower than (i.e. below) the filter cut-off frequency?

Accompanying questions for **extra-credit**:

c) Compute the spectrogram using the data from the other channels. Select one frequency (or average over a frequency band) and subtract or divide by the pre-stimulation amplitude. Plot the average changes during stimulation as a function of depth.

d) Re-plot the a single channel PSDs or spectrogram correcting for the frequency response of the filter (i.e. divide by the filter's response)

Part IV (all for extra-credit): Current Source Density (CSD)

e) Compute the current source density of the average stimulation data. Note that the data now needs to be organized as data(time,channel#). You can achieve this using the following pseudo-code.

```
for m=1:size(data,1),
   csd(m,:)=-diff(data(m,:),2,2);
end;

% plot using
clf,
pcolor(t,channel#,csd'),
view(2), shading('interp'),
set(gca,'CLim',[-1 1]*0.5*min(csd(:))),
```

e) Compute the current source density of the entire filtered data before re-organizing it into individual stimulation trials. You may need to down-sample (e.g. mean, decimate) the data by 10 to ease memory load. Inspect the CSD. Determine if adjusting the filter or the amount of decimation improve the CSD. Justify your selection.

Assignment Checklist

Part III: Spectrogram

20. Filter and plot the data, justify your frequency cut-off selection.
21. Check your filter
22. Calculate the PSD and plot the PSD from one trial and the average PSD from all trials. Any difference?
23. Calculate the spectrogram for a single trial and plot it.
24. Plot the average spectrogram.
25. Answer accompanying questions 25, 26, 27. Also extra-credit c and d.
26. Extra-credit e: Compute CSD
27. Extra-credit f: Plot the average CSD