EEL 5283/4930: NEURAL SIGNALS, SYSTEMS, AND TECHNOLOGY

Spring 2020

Mini Project 2
Due: Friday 03/27/2020

Description

In your previous Mini Project, you were given vectors of spike times where a 1 at an index indicated that a spike had occurred. However, data is not collected in this convenient form. In order to go from raw electrode data to multi neuron spike times, data must go through a multistage pattern recognition pipeline (Figure 1) consisting of: 1) Spike detection, where spike events are detected in the raw data and their times recorded; 2) Spike extraction and alignment, where events are extracted from the raw data and temporally aligned based on their peaks; 3) feature extraction, where characteristics of the event waveform are projected onto principal component space; and 4) cluster cutting and labeling, where boundaries are drawn in the principal component space to segment the spike events and assign them to individual neurons' clusters. This Mini Project will focus on the latter part of this pipeline.

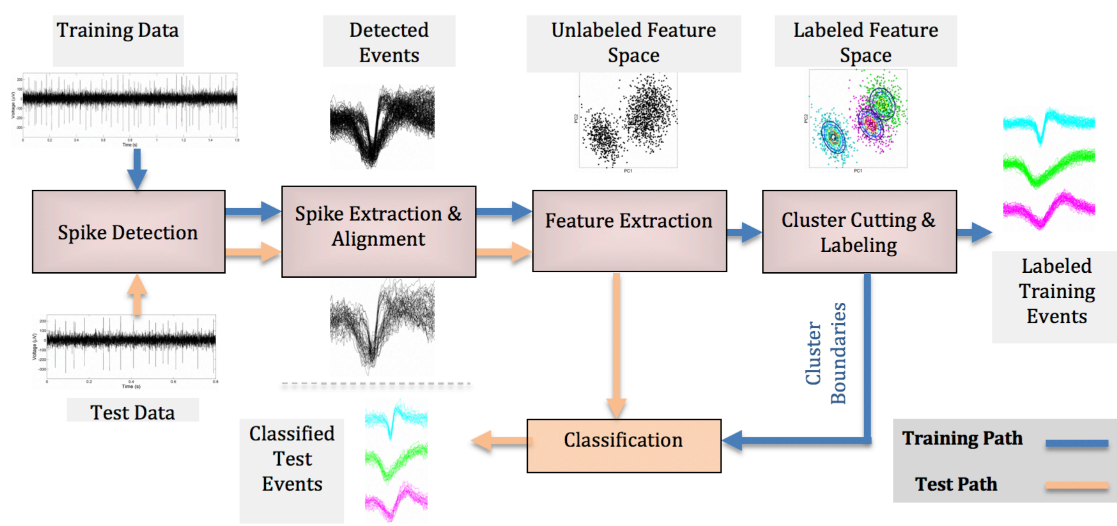

Figure 1: Steps to cluster and classify neuronal signals from ensemble recordings [Ref. Oweiss, 2010 *Statistical Signal Processing for Neuroscience and Neurotechnology*, Academic Press]

In this Mini Project, you are given an ZxY matrix (Spike_Events.mat) containing Z extracted spikes of Y samples each from multiple but unspecified number of neurons. This assignment will ask you to write code, generate plots from this data and interpret those plots. You may use any of the programs written so far as part of the homework in achieving this goal.

Tasks:

0. **Relationship of Variance/Covariance to decision boundaries**
    a) No answer is required for this problem. It is an exercise that will build intuition for tasks 1 and 2 below.
    b) Download the files: Interact_bayes.m, bayes_demo.m and d_function.m from Canvas. Run bayes_demo.m
    c) Move the sliders. This program showcases how the decision boundaries change for gaussian classes with fixed means as the variance and covariance change.
    d) Note how the class boundaries change as you fix variance/covariance and vary the other.

1. **Feature Extraction**
    a) Create a plot of the extracted spikes overlaid over one another.
    b) Perform Principal Component Analysis on the matrix of stacked spike events.
    c) Project the spike waveforms onto the two dominant eigenvectors of the data matrix. Create a scatter plot of the data where the x-axis corresponds to principal component 1 and the y-axis corresponds to principal component 2.

2. **Clustering and Labeling**
    a) Complete Task 0 if you have not already done so.
    b) Cluster the data using a method of your choice. Undergrads may use the "ground truth" templates in their algorithm while grads may not. Give the variance within and covariance between each cluster as part of your answer.
    c) Label spike events based on which cluster they fall into. Be sure to plot your decision boundaries. Compute the average of all spike events in a cluster and compare it to the "Ground truth" templates. Try to get as close as possible.
    d) Create a plot as in 1(a) for each class of spikes. Overlay the mean waveform in bold.
    e) Comment on the optimal decision boundary you found in terms of the extent to which it captures the variances/covariances within each individual class.