CPSC 453/553 Final Project

Clustering Methods to Classify Neurons Involved in Declarative Memory

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Declarative memory is a type of memory that requires conscious recall of events or objects, and involves activity of the medial temporal lobe (MTL) system. This type of memory has been studied extensively using single electrode recording from various animals, but has rarely been done in humans due to invasiveness. This dataset[1] collected by Faraut et al (2017)[2] includes single neuron firing data recorded from the amygdala and hippocampus (part of the MTL) of humans participating in a declarative memory task recorded during epilepsy surgery. In this task, patients were shown a series of images of different categories (e.g. houses, landscapes, animals) and asked whether this was their first time seeing them (novel) or if the image had been seen previously (familiar). Faraut et al were able to record and isolate 633 hippocampal and 943 amygdala neurons during this task, and investigated the firing activity of these cells. They isolated two types of neurons based on activity-- Visually Selective (VS) neurons, which respond to different categories of images, and Memory Selective (MS) neurons, which respond differently to novel and familiar images. The task at hand is to identify which neurons are VS, MS, or both, and not every neuron falls into one of these categories.

The authors of the paper include a repository containing code they used to process the data. They use statistical methods to detect possible VS and MS neurons. In selecting for VS neurons, they use a 1x5 ANOVA with $p<0.05$ to find cells whose response after stimulus onset significantly differs among each visual category of the images used in the test. For MS neurons, they used a two-tailed, bootstrap comparison of means to find neurons whose response significantly differs between novel and familiar images. Using these methods, the authors classified 250 neurons as VS neurons, 118 as MS neurons, and 20 as both VS and MS neurons. We hope to use this classification as a baseline to compare our results.

We are interested in exploring clustering methods to detect VS and MS cells, both to find a qualitative justification for the cell labels, and to find any cells that may not have been detected by the statistical methods used in the paper. We are also interested in patterns of firing that are exhibited by VS and MS neurons. Potential methods include PCA, K-means, and spectral clustering of neural firing data to start, and we will explore any adjustments to these algorithms if needed. One challenge that we anticipate is the assignment of multiple labels to a single neuron, such as the classification of a neuron as both VS and MS. We will investigate methods to assign multiple labels, while hopefully keeping the noise of multiple assigned labels relatively low. If this succeeds, we hope to come up with a generalized algorithm for clustering while assigning multiple labels.

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[1] Dataset link: https://datadryad.org/stash/dataset/doi:10.5061/dryad.46st5

[2] Faraut et al: https://www.nature.com/articles/sdata201810