Di Mao

BIOEN 217

30 November 2022

Visual Neuron Decoding - Final Project Report

Summary

This project aims to determine the visual stimulus of a single neuron in the visual cortex of mice. Data was collected from an experiment of one neuron of an immobilized mouse watching a video of random white noise. The first part of the data is called `spiketrain`, a vector of the times at which the neuron fired (1 for fired, 0 for not fired), also called a spike. The second part of the data is called `stim`, a 3D array of the white noise, size 11x11xtime. Combined, at each time, we have both an indication of whether there was spike, and if there was, the respective white noise displayed.

To find the visual stimulus, we combine all the visuals displayed when there is a spike. However, because our visuals are of white noise, if we just combined, or add, these visuals, our resulting figure will also have noise.

Noise follows a standard normal distribution. The mean of a standard normal distribution is 0. This means, if we average all the visuals, the noise should approach 0. The resulting visual would have little noise, and we just have a visual stimulus.

The most direct approach following this would be to loop through `spiketrain`, determine where the vector values are 1, and then find the average of all these visuals. With no other modification, we obtain the following visual stimulus:

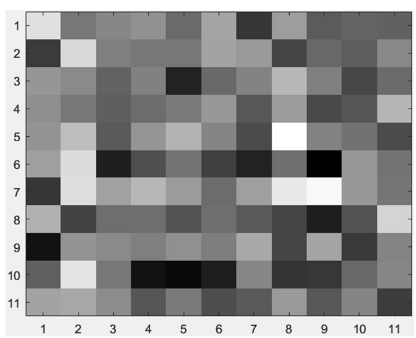

Figure 1 Original Visual Stimulus

When viewing this stimulus, it is clear that there is no shape that is being represented. We want to find the shapes that the neurons respond to.

The reason for this unclear visual stimulus is because of delays, due to neurons that do not immediately respond to their stimuli. Because this delay is constant for both the stimulus and the visual, we can think of the example we performed above with no changes as a delay of 0.

By modifying this delay, we may be able to obtain a clearer visual stimulus. To achieve this stimulus, we sum the visuals not at the exact time as found from `spiketrain`, but instead at times before, as specified by delay. For instance, if we want to find the visual stimulus of when the delay is 1, we average the visual stimuli at 1 before the specific spike times.

Next, we try out some of the delays. For instance, let's try delays from 0 to 15. We obtain the following visual stimuli (left to right top to bottom by delay):

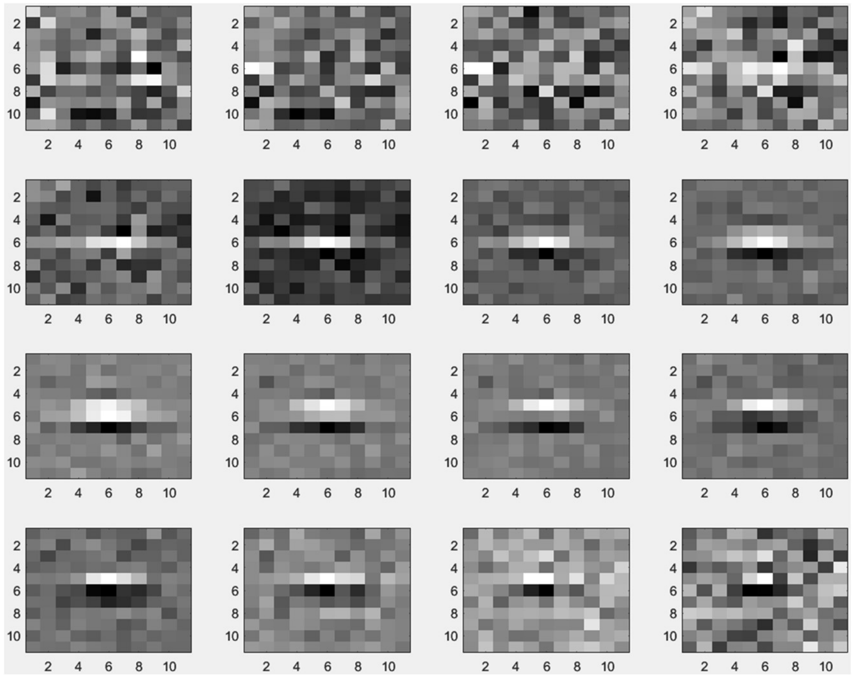

Figure 2 Visual Stimuli with Delays 0-15

From the visual stimuli, we recognize that the clearest visual stimuli occurred at delays of 5 and 10.

Therefore, the visual stimulus of the spike are lines. This can be either one or two lines, and they are horizontal.

Code

```
% Di Mao
% BIOEN 217
% 12/10/2022
% Final Project Visual Neuron Decoding

% clear all variables and figures
clear all; close all; clc

% load in the visual neuron data
data = load('\Users\Di\Documents\UW\BIOEN 217\Final Project\VisualNeuronData.mat');
% spikeTrain
%   - vector, spiking data
%   - 1 for fire, 0 for not fired
spikeTrain = getfield(data,'spikeTrain');
% stim
%   - 3D array, white noise
stim = getfield(data,'stim');

% determine the sizes of the given data
szSpikeTrain = size(spikeTrain);
% 24000 1
```

```
szStim = size(stim);
% 11 11 24000

% create a vector of all times with a spike
timesWithSpike = [];
for time = 1:szSpikeTrain(1)
    if spikeTrain(time) == 1
        timesWithSpike = [timesWithSpike, time];
    end
end

% plot the stimulus with the given delay
%   - delay is currently set to 0, but can be manually changed
delay = 0;
% sums the stimulus at the time of spike, factoring in delay
sumStim = zeros(szStim(1),szStim(2));
for timeSpikeVal = timesWithSpike
    for i = 1:szStim(1)
        for j = 1:szStim(2)
            sumStim(i,j) = sumStim(i,j) + ...
                stim(i,j,timeSpikeVal - delay);
        end
    end
end
% averages the stimulus at the time of spike, removes noise
avgStim = sumStim ./ length(timesWithSpike);
% plots the averaged stimulus
colormap('gray')
imagesc(avgStim)
```