Problem 3

Out[1]: Toggle Code

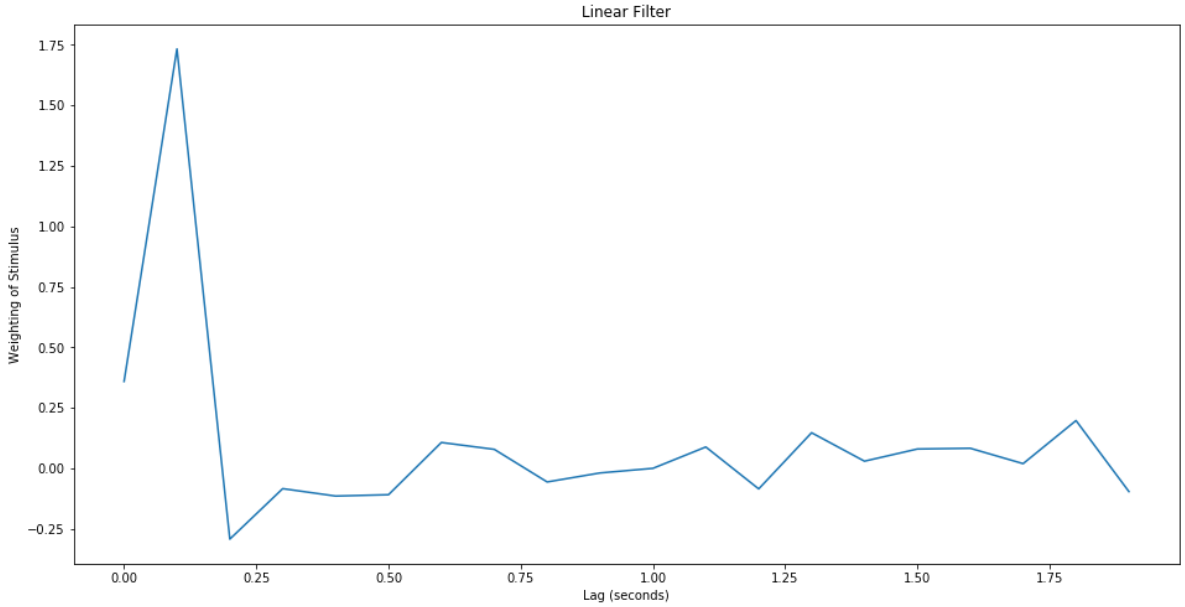
Methods

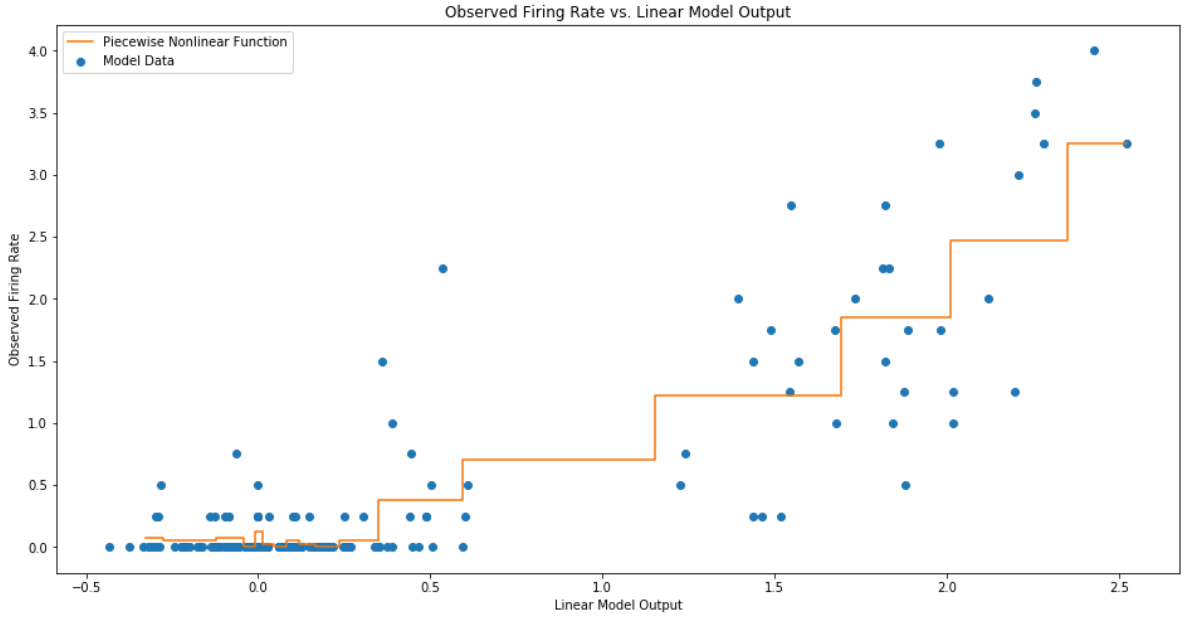
We implement a LN model to model the spiking behavior of a neuron. The given stimulus for each of the 5 trials was transformed into a stimulus matrix. Each row of the stimulus matrix is a 2 second window on the stimulus vector, starting from the 0 - 2 s interval and increasing by 100 ms each row. For the response vector, we used the first 4 trials for building our model, while the 5th model was used as a comparison. The linear portion of the LN model was built by minimizing the square error between the response vector, R, and the matrix product of the stimulus matrix, S, and linear filter, W. To solve this system, we find the pseudo-inverse of S, and matrix multiply it with the response vector R, allowing use to find the best fit linear filter, W, to the data.

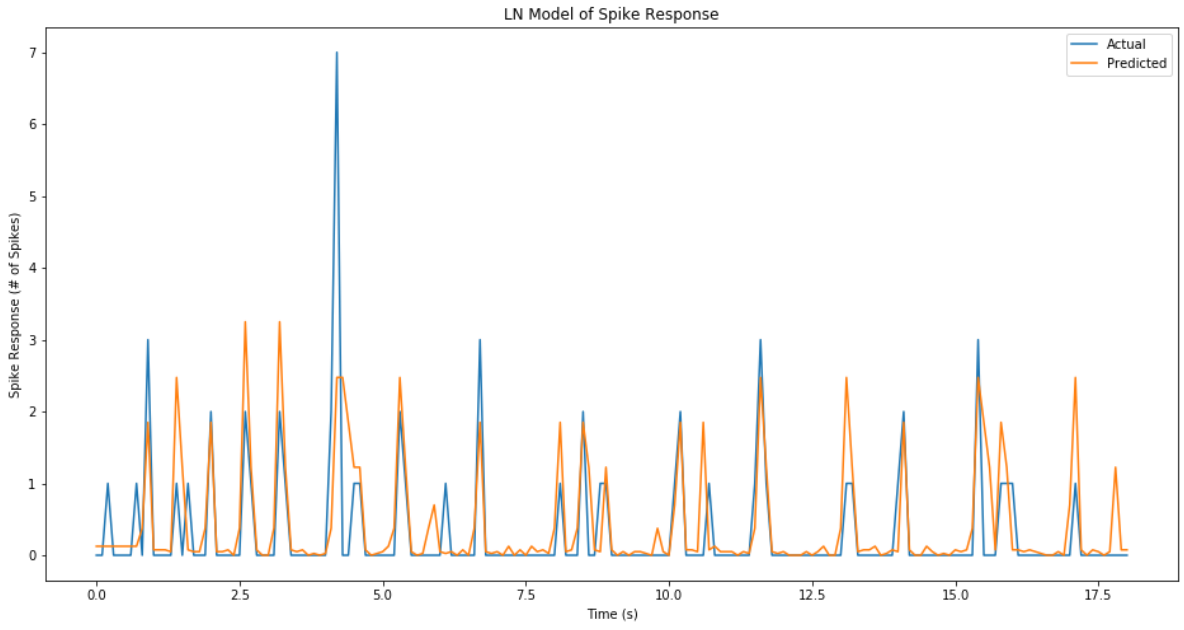
$$W = (S^T S)^{-1} S^T R$$

For the non-linear portion of the model, we build a piecewise function by plotting the linear model output vs. the model response vector. After sorting the values of the plot, we bin every 10 points of the sorted plot, averaging the values in each bin to create a piecewise nonlinear function that maps the linear output to a non-linear output. We plot the output of the LN model against the response vector of the 5th trial for comparison.

(i) LN Model


Linear Filter
Weighting of Stimulus
Lag (seconds)


Observed Firing Rate vs. Linear Model Output
Piecewise Nonlinear Function
Model Data
Observed Firing Rate
Linear Model Output


LN Model of Spike Response
Actual
Predicted
Spike Response (# of Spikes)
Time (s)

Discussion

Examination of the linear filter reveals that the weight of the stimulus is highest very close (temporally) to the response of the spike. This seems to indicate that the past values of the stimulus contribute little to the spike response. The non-linear portion of the model seems to indicate that linear model slighlty underestimates the spike response. The non-linear step corrects for this by creating the appropriate mapping from the the linear output to the predicted firing rate. Finally, when we compare the output of the LN model to the spike response of the 5th trial we can see that it mostly predicts the firing rate fairly well, excluding outliers (e.g. the 5th trial spike respinse peak at around 4 s).