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NEUR 603 Assignment 3

Part 1

A white noise input was generated, and this input was fed to the model neuron; the cross-correlation of the input and output was subsequently computed. The filter was then normalized and adjusted to match the actual filter length (a vector of length 50). The filter is plotted in Figure 1.

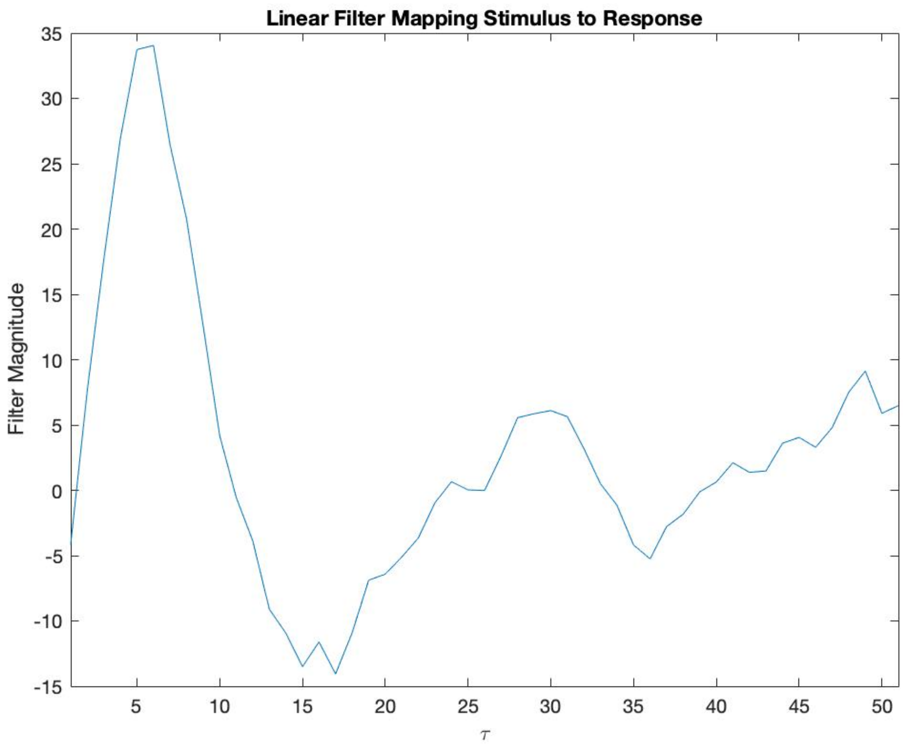

Figure 1 - Normalized linear filter mapping the stimulus to response (lags from 0 to 50 shown)

The filter was convolved over the white noise stimulus to obtain a predicted output. The predicted output is plotted against the actual output in Figure 2. The static nonlinearity is visualized in Figure 3. The parameters for the best fits were found by minimizing the mean square error (MSE) and the mean absolute error (MAE) between the static nonlinearity in the model and the static nonlinearity equation (equation 2.3 of Dayan & Abbott).

The MSE between the estimated and observed responses for various lengths of the input vector are shown in Figure 4. Figure 4 was generated by averaging the MSE the estimated and observed responses of 10 white noise input vectors of length varying from 100-5000. The minimum MSE is achieved by applying a static nonlinearity that was optimized to minimize the MSE. When this static nonlinearity is applied to the predicted output, the response in Figure 5 is generated (plotted against the observed response).

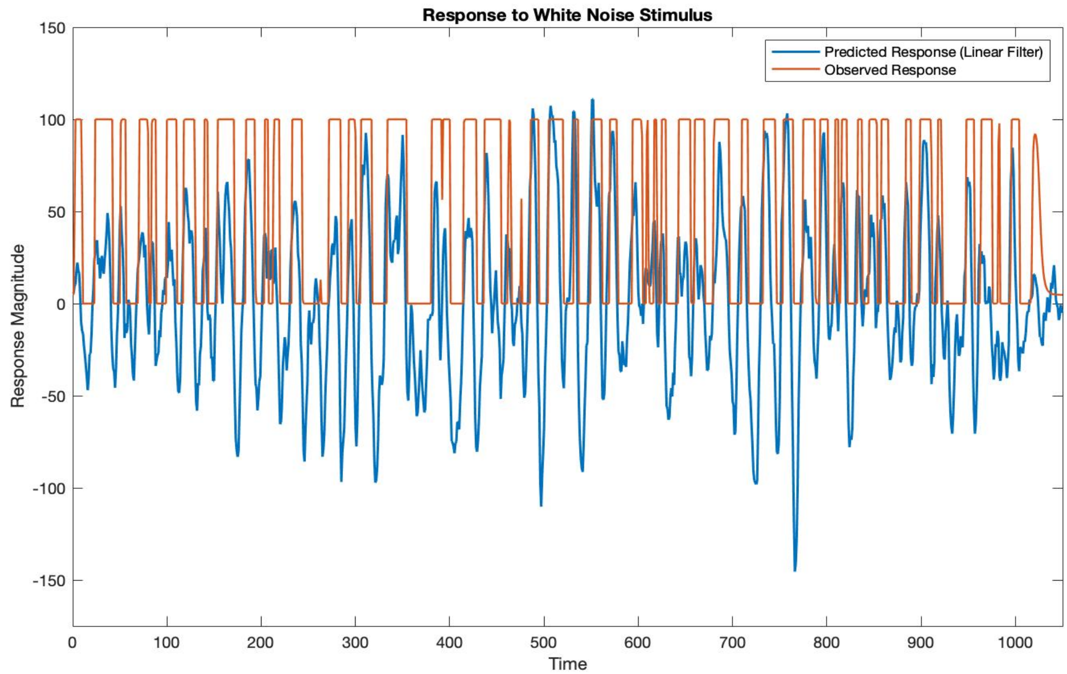

Figure 2 - Predicted output (blue) of the linear filter from Figure 1 to a white noise stimulus; the observed response (orange) to the same stimulus is also plotted

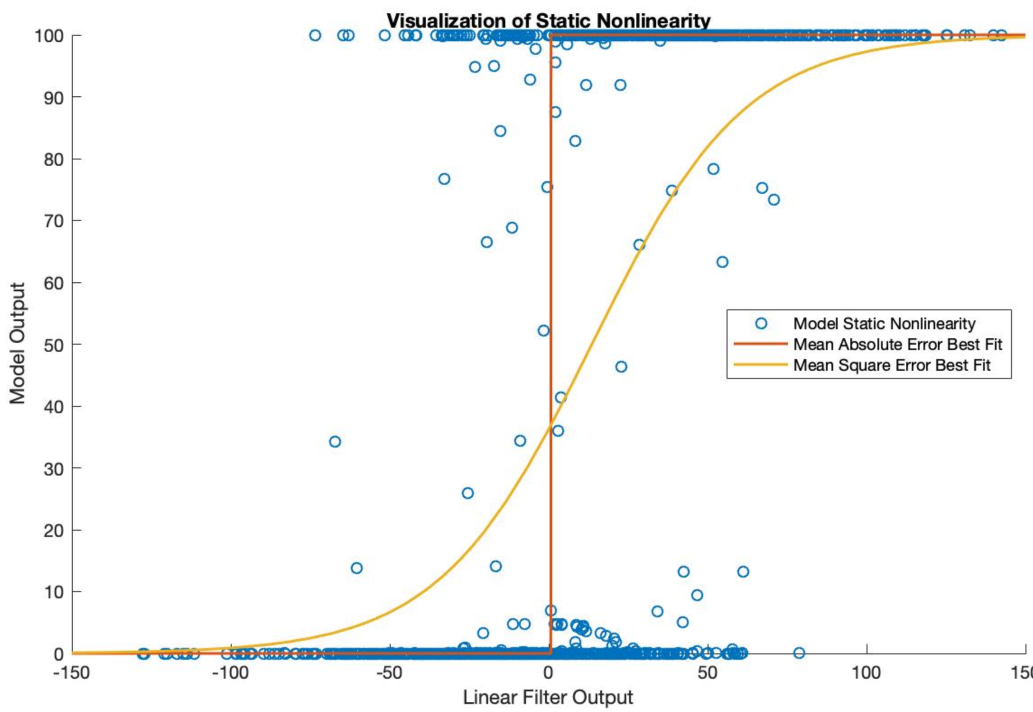

Figure 3 - Model output values predicted by the linear filter plotted against the actual observed output values to illustrate the static nonlinearity in the model; the parameters of a static nonlinearity that minimizes the MSE and MAE were computed and these nonlinearities are shown in yellow and orange, respectively

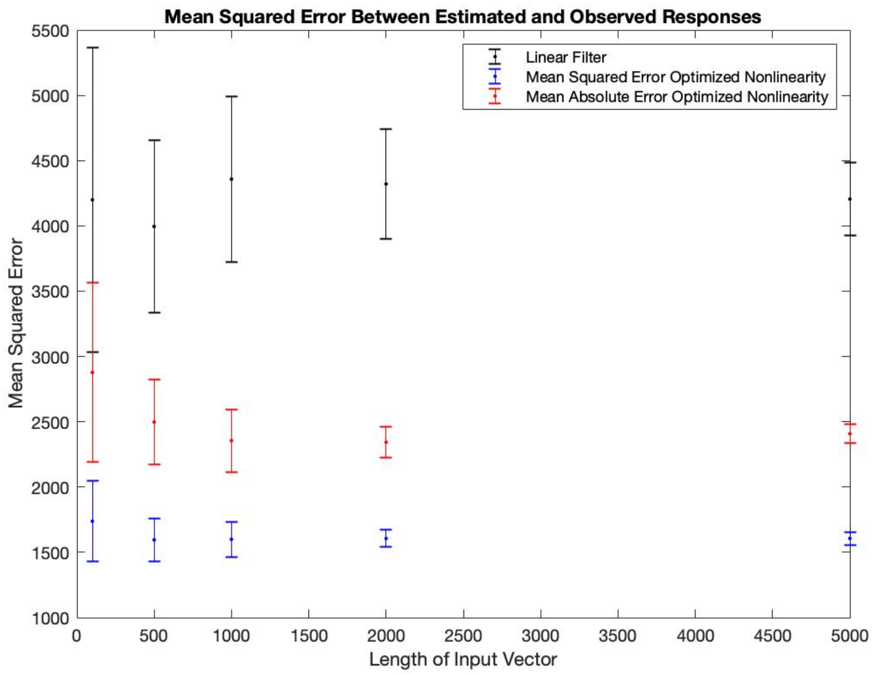

Figure 4 - MSE between the predicted and observed responses for white noise vectors of varying lengths, averaged across 10 trials. Note the minimum MSE is achieved by applying a static nonlinearity to the filter output that was optimized to minimize the MSE

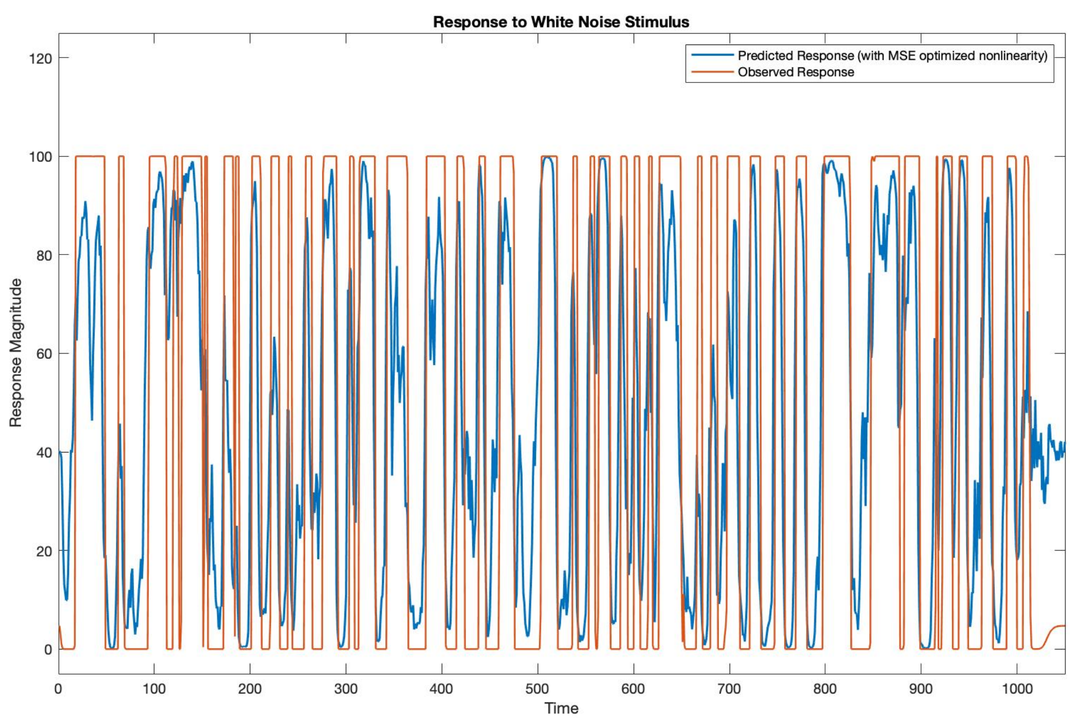

Figure 5 - Predicted response (blue) to s white noise stimulus, using the linear filter from Figure 1 with application of a static nonlinearity optimized to minimize MSE; the observed response (orange) to the same stimulus is also plotted

Part 2

An input consisting of a time series of 12000 20 x 20 white noise images was generated and this input was fed to the model neuron. The spike triggered average of the spatial receptive field was computed using equation 1.19 from Dayan & Abbott. Figure 6 shows the spike triggered average for $\tau \epsilon\{1, 8\}$. From Figure 6, it is clear that **the neuron prefers diagonal bars of light, -45° from horizontal** (yellow regions in the image correspond to input regions that are brighter; green regions correspond to input regions that are darker). This is especially obvious for $\tau = 3{,}4$, and 5.

The spatial receptive field at the trough of the temporal response, i.e. for $\tau \epsilon\{13, 20\}$, is shown in Figure 7. Here, we see that **the receptive field is the inverse of that in Figure 6** — the diagonal bar is darker and the surrounding region is typically lighter, which as expected quiets the activity of the neuron. This is especially obvious for $\tau = 14{,}15$, and 18. The receptive field for this simple V1 neuron is thus an diagonal bar oriented at -45° that is darker than the surrounding region, and then approximately 5 ms later, the bar flashes on (i.e. a flashing diagonal bar).

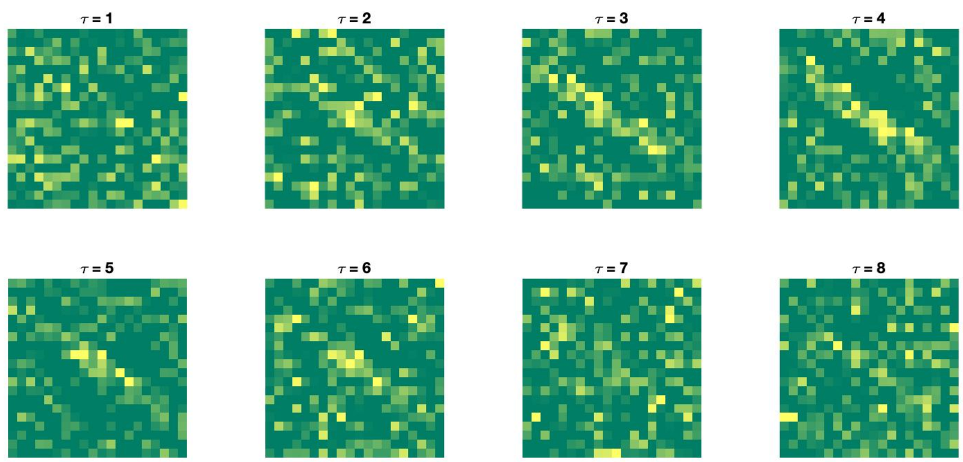

Figure 6 – Spike-triggered average (spatial receptive field during temporal response peak). Yellow regions correspond to brighter regions of the stimulus

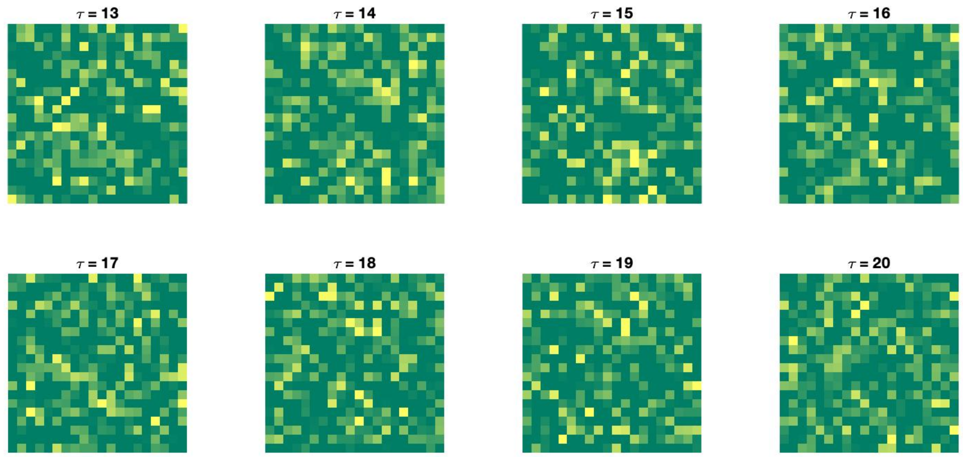

Figure 7 - Spatial receptive field during temporal response peak. Yellow regions correspond to brighter regions of the stimulus