CAPTURING SLOW CONTRAST ADAPTATION OF RETINAL GANGLION CELLS WITH A GENERALIZED LINEAR MODEL

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Neurons throughout the visual system adapt to the statistics of visual inputs. In particular, the spike rates of retinal ganglion cells (RGCs) adapt to changes in luminance and contrast over several seconds (Smirnakis et al. 1997; Chander & Chichilnisky 2001; Baccus & Meister 2002). This observation is rarely accounted for in functional models of RGC response. The class of generalized linear models (GLMs) is easily fit to spiking data and can effectively characterize primate RGC responses to white noise (Pillow et al., 2008), but its ability to explain adaptive responses to non-stationary stimuli remains unexplored.

To address this question, we recorded macaque parasol RGC responses to a highly non-stationary stimulus consisting of a Gaussian signal modulated by a log-normal contrast envelope with spatiotemporal correlations matched to those of natural scenes (Frazor & Geisler 2006). Figure 1 shows an example frame of this stimulus. In a GLM, a neuron's instantaneous firing rate is modeled as the exponentiated linear combination of time-varying explanatory variables such as the stimulus and spiking history (Truccolo et al., 2005) of itself and any afferents. We parametrized the GLM to allow long time scale effects of spiking history (up to six sec), and fit the model by maximizing the likelihood of the data.

We cross-validated the fitted model on repeated stimuli with the same non-stationary statistics and found that the predicted PSTH's matched the true PSTH's (average of 0.76 and 0.83 correlation for 20 ON and 85 OFF cells, respectively). We also examined predicted responses of the same fitted model to a contrast-switching stimulus known to induce slow contrast adaptation (Smirnakis et al., 1997; Fairhall et al., 2001). Despite the difference between fitting and test stimuli, the model exhibited slow contrast adaptation that matched that observed in the corresponding cells responses (see Figure 2). The fitted model produces this behavior through a slowly decaying inhibitory effect of previous spikes.

We conclude that GLMs provide a flexible framework for capturing long time-scale behaviors such as slow contrast adaptation in RGCs. We are currently exploring the capacity of the model to explain other adaptive phenomena such as adaptation to naturalistic fluctuations in luminance and fast contrast gain control.

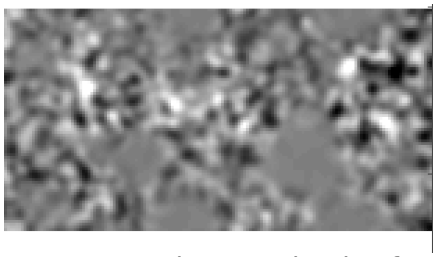

Figure 1: Non-stationary stimulus frame

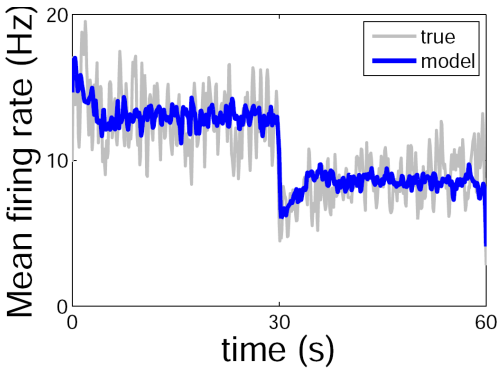

Figure 2: Trial-averaged response of 1 cell to contrast-switching stimulus