Stimulus-dependent correlations in threshold-crossing spiking neurons

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Abstract:

We consider a threshold-crossing spiking process as a simple model for the activity within a population of neurons. Assuming that these neurons are driven by a common fluctuating input with gaussian statistics, we evaluate the cross-correlation of spike trains in pairs of model neurons with different thresholds. This correlation function tends to be asymmetric in time, indicating a preference for the neuron with the lower threshold to fire before the one with the higher threshold, even if their inputs are identical. The relationship between these results and spike statistics in other models of neural activity is explored. In particular, we compare our model with an integrate-and-fire model in which the membrane voltage resets following each spike. The qualitative properties of spike cross-correlations, emerging from the threshold-crossing model, are similar to those of bursting events in the integrate-and-fire model. This is particularly true for generalized integrate-and-fire models in which spikes tend to occur in bursts, as observed, for example, in retinal ganglion cells driven by a rapidly fluctuating visual stimulus. The threshold-crossing model thus provides a simple, analytically tractable description of event onsets in these neurons.

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