

## Maximum entropy modeling of multi-neuron firing patterns in V1

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Understanding the activity of a network of neurons is challenging due to the exponential growth in potential interactions as the network size increases. In the visual cortex, the firing activity of pairs of neurons is correlated over a few tens of milliseconds, but the source and significance of these correlations is controversial. Correlations may reflect genuine interactions between pairs of neurons or driving by a common input.

One way to investigate the structure of neuronal correlations is maximum entropy modeling. Maximum entropy modeling generates canonical joint firing distributions that are consistent with a certain set of constraints but are otherwise as unstructured as possible. In particular, maximum entropy models can be formulated from constraints derived from pair-wise interactions, or alternatively, from a common-input model. Recently, maximum entropy techniques have been used to study the structure of multi-neuron firing patterns in the retina (Schneidman et al. 2006 and Shlens et al. 2006); in this context, pairwise-interactions appear to account for multineuronal firing patterns. Here, we implement a similar analysis of multi-neuron firing patterns from tetrode recordings in the primary visual cortex of the anesthetized macaque.

One caveat to multi-neuron analyses of tetrode recordings is that when neurons fire within a millisecond of each other, spikes can be misclassified or dropped, leading to a systematic underestimate of simultaneous events. We (conservatively) correct for this underestimate, by postulating that correlations on the order of a millisecond are no stronger than correlations on the order of ten milliseconds.

As in the retina, we find that weak pair-wise interactions between neurons imply significant departures from independence in multi-neuron firing patterns, and lead to a prevalence of simultaneous multi-neuron activity. We also find that a simple common-input model, with constraints on the probability that a neuron fires when any other neuron fires, also captures much of the observed departures from independence. We derive Bayesian estimates of likelihood ratios for the pair-wise and common-input models and show that, for a range of priors, the pair-wise model is more likely than the common-input model. Thus, it appears that in V1, at least within the range of a hundred microns, most of the structure in multi-neuron firing patterns can be explained on the basis of interactions between pairs of neurons

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