Ising Models for >40 Ganglion Cells in a Dense Patch of Salamander Retina

Dario Amodei, Greg Schwartz, and Michael Berry

Princeton University

Recent work (e.g. [2, 3]) has shown that the collective spike patterns of groups of up to 40 ganglion cells in the retina can be represented to high accuracy by a fully-connected Ising model constructed from the pairwise correlations of the cells’ spikes. Extending this work, we investigate the accuracy of fully-connected Ising models for groups of >40 densely clustered retinal ganglion cells in salamander. We construct Ising models for each of three types of stimuli: natural scenes, random checkerboards, and geometric shapes. To make these measurements we have fabricated a multielectrode array with 60 channels in a square pattern and a 30 μm interelectrode spacing (figure at bottom). The array has features down to 2 μm and is fabricated using a combination of photolithography, electron beam lithography, lift-off, and dry etching. The fabrication process is a modified version of that of [1]. We also report progress on the fabrication of a 240 channel array (also with 30 μm spacing), which will be used to construct even larger Ising models and to test the hypothesis [3] that dense patches of ~200 correlated cells can be approximated by an Ising model poised near a critical point. We explore the energy landscape of our Ising model and compare it with the energy landscape of Ising models from simulated networks. To test the idea that the energy basins of large Ising models represent feature classifications by the retina, we compare basin identity with shape identity for Ising models constructed from the geometric shapes dataset and determine the mutual information between the two. We also test the relative strength of noise correlations versus stimulus correlations by shuffling spike trains on each cell independently over repeated presentations of the same stimulus.

References