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Neural computation from retina to visual cortex

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The aims of our research are: 1) To develop models of neural computation in the retina that can predict the observed ganglion cell spike trains under a broad variety of visual stimuli. 2) To analyze what neural computations the visual cortex might perform based on the observed structure of retinal signals. I will report on two projects in this effort.

1) Retinal ganglion cells rapidly switch from Off-type to On-type. One generally distinguishes ganglion cells by whether they are excited by an increase (On-type) or decrease (Off-type) in light intensity. We found that certain ganglion cells switch from one type to the other. The switch is triggered by peripheral stimuli far from the receptive field center and lasts ~100 ms. We show how this dynamic rerouting of signals is accomplished by retinal interneurons. Similar switcher circuits are likely of general use in neural computation.

2) A cortical network for optimal visual acuity in the presence of fixational eye movements. Humans can reliably discriminate visual features with a retinal size of ~2 photoreceptors, even though fixational eye movements smear the retinal image across distances of ~30 photoreceptors. What kind of computation can extract fine spatial detail despite the rapid scanning of the image over the receptor array? Starting from simple models of the retinal response and the eye movement statistics, we derive the mathematically optimal computation. We find that this “ideal observer” computation can be mapped onto known circuits of early visual cortex.

Project (or PI) website

http://rhino.harvard.edu/