Learning extrastriate neuronal selectivity with redundancy reduction

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Statistical approaches to study the properties of neurons in sensory system ascribe the selectivity of neurons in visual and auditory cortices to regularities of signals in natural environment. “Efficient coding” hypothesis is an outstanding theory that explains the work of sensory system in discarding unnecessary data and supplying higher order brain areas with the most informative features in sensory input.

Based on this hypothesis, several models have been developed that simulated different properties of neurons in primary visual cortex. For example, sparse coding and ICA models developed neurons that were similar to V1 neurons in selectivity for orientation and spatial frequency. This was done by removing redundancies between responses of neighboring neurons. However these models are confined to functional properties of neurons in area V1 and cannot be extended to model the selectivity of neurons in extrastriate visual areas like V2.

In this paper, we propose a neural network based on local redundancy reduction, to model the feature selectivity in area V2. The main idea is to use redundancy reduction in different spatial extents of different model layers. We show that with inhibitory signals from surround in the first layer of the model, redundancies in responses of neurons in local neighborhoods are eliminated. A two layer neural network is implemented with local inhibitory connections. Weights of these connections are learned from a set of natural images to reduce redundancies in input image. Response of each neuron in this model is rectified and then divided to a weighted sum of responses of its neighboring neurons.

Neurons in area V2 are selective to visual features of intermediate complexity like angles and junctions. We examined the selectivity of neurons developed in the model with a set of stimulus composed of gratings and contour segments. These stimuli were used previously to probe the selectivity of neurons in visual area V2. We show that neurons in the proposed model can simulate the properties of V2 neurons revealed in electrophysiological experiments.