Analysis of optical images of cortex using parallel support vector machines

Ravi Rao[1], Guillermo Cecchi[1], Youping Xiao[2], Ehud Kaplan[2]
(1: IBM Research Division, Yorktown Heights NY 10598
2: Mt. Sinai School of Medicine, NY 10029)

Optical imaging of primate cortex is an important tool in understanding brain function[1]. Optical imaging provides high spatio-temporal resolution and is more convenient to use than direct electrical recordings. However, a major hurdle in using optical images is the difficulty in processing and interpreting the large data volumes collected.

A typical experimental paradigm is to expose a primate to specific visual stimuli and capture optical images of cortical activity. We then wish to determine which specific areas in the cortex are responsible for processing visual attributes such as orientation or color. This problem has usually been tackled with univariate statistical models. However, as shown in recent publications [1][2], it is advantageous to employ multi-pixel or multi-voxel methods to analyze patterns of activity. These techniques utilize information in the immediate neighborhood of a pixel to determine that pixel's sensitivity to experimental conditions. The success of these multi-pixel methods is due to the fact that the sensitivity of the analysis increases with the use of additional neighborhood information.

This approach leads to the use of a supervised classifier paradigm, where an experimental condition is a class label, and the size of the neighborhood constitutes the input dimensionality. We use support vector machines for classification, because of their superior properties. We compute the classifier accuracy for a pixel using cross validation, which is a measure of the ability of a pixel to predict the experimental condition.

Though this classifier design yields promising results, it is computationally intensive. We have designed a parallel implementation that runs on IBM's BlueGene supercomputer that can solve the problem in a few hours with a few thousand processors, rather than several years on a single processor machine. This implementation provides a new capability to biological scientists.

We also created a new classifier design as follows. We select label subsets for the supervised class labels based on the entropy associated with each label subset. This permits interpretations where the pixel activity is based on a combination of experimental conditions, rather than on a single condition.

We present the results of applying the parallel SVM based classification on data gathered from the primary visual cortex (V1) of macaque monkeys. The results show that orientation information is distributed more evenly and widely compared with color information. We also present results of using the new classifier design on data from macaque visual cortex.

References:

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2) “Beyond mind-reading: multi-voxel pattern analysis of fMRI data”, KA Norman, SM Polyn, GJ Detre, JV Haxby - Trends in Cognitive Sciences, 2006.