Stats 312, Exercise 1 Due Jan 15

Introduction

In the following weeks we will analyze functional MRI data measuring the brain's response to visual images. The data is provided by the Gallant Lab in Berkeley, which has kindly made this data publicly available through the crcns.org data-sharing website.

http://crcns.org/data-sets/vc/vim-1/about-vim-1.

More information can be found in the Kay et al paper, which I've posted to coursework.

Basic information:

The experiment consists of two (2) human subjects viewing a sequence of cropped photos of everyday objects, while they are scanned in an fMRI. The images are shown in several long sequences. BOLD responses are extracted at thousands of voxels in the visual cortex.

This data was collected to (a) develop and test encoding models that can predict how the brain responds to naturalistic stimuli, and (b) to decode images from the brain.

The data was collected in two batches:
Training set, consisting of 1750 distinct images per subject, each repeated 2-3 times.
Validation set, consisting of 120 distinct images, each repeated 13 times. This data was measured in block of 12 images x 13 repeats.

Data:

At this point, I only provide all validation trials for the 1331 voxels that were mapped to the V1 area. Later we will look at the complete data set.

All datasets are found in the following link in csv or RData formats:

http://statweb.stanford.edu/~yuvalben/stat312/dataset_1/

valid_stim.csv	- 120 x 16384	stimuli matrix (120 images of 128^2 pixels each)
valid_index.csv	- 1 x 1560	indices of validation images shown at each slot
valid_single_v1.csv	- 1331 x 1560	fMRI response voxel i at slot j
v1_locations.csv	– 1331x3	xyz coordinates of each voxel in v1.

From R you can directly use

```
load("http://statweb.stanford.edu/~yuvalben/stat312/dataset_1/valid_index.Rdata")
```

Instructions

In the first assignment we compare the response of a voxel to different images. We look at voxel 100 first (`valid_single_v1[100,]`). For Thursday, please prepare one of the analyses discussed in two slides; one slide should describe the methods/model/assumptions/analysis, and the other should display the results. Make sure that a figure or table of results is reasonably annotated.

A. Comparing two images

Estimation: Take a block of 12 images that was estimated together. Choose two images you would like to compare. Estimate the difference between the mean response of the voxel to the first image with the mean response to the second image.

Inference: Pose this as a hypothesis testing problem. Estimate the p-value that there is a significant difference between the groups. What were your assumptions?
Try to put confidence intervals on the estimated effect.

Assumption checking: Plot the data, the residuals, etc; does there seem to be a difference between the images? Do the model assumption seem to hold?

B. Comparing two and more image groups

Take a block of 12 images that was estimated together (perhaps a different block). Divide the images into two groups that illustrate a perceivable contrast. (The groups do not have to include all 12 images). Your goal is now to estimate the difference between the mean response of the voxel to images of the two groups. Repeat the steps from above (Estimation, Inference, Assumption checking).

Try to estimate the overall effect of the image factor. This should give you the SNR of the voxel response. (Note: this is tricky).

C. Advanced

Choosing the hypotheses for A and B: You might want to try to hypothesize about the role of the function before choosing the 2 images or 2 image groups. If you'd like, you can use the training data or other blocks other blocks. Can you visualize the images and the average responses in a way that is easy to observe and think about.

> Hint: Neurons (and by aggregate, voxels) in early visual areas such as V1 would tend to be influenced only a part of the image (the 'receptive field'). You can try to approximately estimate what is the sensitive area in the image.

Creating a statistical map: The file `v1_locations.csv` contains x,y,z coordinates for each voxel. Repeat the procedure and generate a test statistic for voxels of a single 2-D slice, and try to create an image showing the values of the contrast for each point in a 2-D slice of the brain. These “Statistical parametric maps” are often the object of spatial inference in function MRI analysis.