Team Zeta Project Proposal

Visual Object Prediction by Machine Learning: Object Category Approximation Using Non-Maximal Voxels

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The paper, *Distributed and Overlapping Representations of Faces and Objects in Ventral Temporal Cortex*[1], collected data from a sample of six subjects of which consists of five females and one male. It presented eight categories of stimuli, faces, houses, chairs, animals, shoes, bottles, tools, and control (phase-scrambled images), to each subject, and wanted to answer the question: if we present different categories of picture stimulus to a subject, whether each stimulus category would evoke the same of category-specific pattern of response in the ventral object vision pathway, and whether we could distinguish individual categories from the patterns of response evoked. Each subject were placed into the functional magnetic resonance imaging (fMRI) for 12 times thus generating 12 time series data. For each time of scanning, it began with 12 seconds of rest, followed by eight stimulus blocks of 24-s duration, one for each category and separated by 12-s intervals of rest, and ended the procedure with another 12 seconds of rest. During each 24-s stimulus blocks, stimuli were presented for 500 ms followed by an interstimulus interval for 1500 ms, thus presented a total of 12 stimuli during each stimulus block and 96 stimuli in a complete experiment run.

The data collected for each subject were split into two sets: odd runs and even runs. Correlation were used as indices of response similarity, and from analyzing within-category correlation and between-category correlation, the result suggested that category-specific patterns of response were distributed and overlapping. The result brought a new question of whether each stimulus category evoked a distinct pattern of response in cortex that responded maximally to other categories. To test whether the patterns of non-maximal responses carry category-related information, voxels that responded maximally to either category were excluded from calculation of correlations. It turned out that removal of maximally responded voxels from correlation calculation barely diminished the accuracy of identification. The research reached a conclusion that the pattern of large and small responses, not just the location of large responses, carry category-related information, and small responses are an integral part of the representation.

The dataset for this paper could be found on OpenfMRI database and is curated and available for download. This 2 GB dataset (ds105) contains files that describe the details of this study: general information of this study (README file), research articles associated with this dataset (references.txt), detail information and update for this released dataset (release_history.txt), the MR repetition time for this study (scan_key.txt), the name of this study (study_key.txt), the major task for this study (object viewing) (task_key.txt). Besides, the models folder contains two files showing the key conditions (the list of the object category) for this study (condition_key.txt) and the comparison setting in this study (tast_contrasts.txt). On top of these, each individual subject has his/her own directory to store the detail results. In each of these directories, there are four sub-directories: anatomy, behav, BOLD and model. The anatomy sub-directory contains the high resolution scanning for the head of the subject (highres001.nii.gz), the mask to get the "brain only" portion from the scan (highres001_brain_mask.n ii.gz) and the "brain only" anatomy result (highres001_brain.nii.gz). The behav sub-directory does not contain information since subject behavior does not contribute to this study. The model sub-directory contains detail information, especially the onset time in seconds starting at zero, duration and weighting for each conditions (object category) for the 12 task runs in this study. The BOLD sub-directory contains the fMRI results for all the 12 task runs from this specific subject. In each task run directory, we can find the fMRI result (bold.nii.gz) and a QA sub-directory containing the time series analysis report and the preprocessing of the fMRI results during each task run, nii files representing the visual of the brain while looking at specific objects, and confound files for the fMRI result in this study.

The approach we are taking to explore the data is as follows. First, we will pre-process and clean the data in order to produce a dataset for easier manipulation. Then, we will be conducting statistical analysis to find if there is interesting correlations among the subjects and their scans. For example, we can study whether the fMRI pattern for different categories are significantly different between each other, within individual subjects, and across different subjects. The Kruskal-Wallis test will be used for this particular example. In addition, we will utilize machine learning methods to build models predicting fMRI blood flow, hence determining what objects people are seeing based on past training data. Some regression techniques that are available to use for fMRI data include ridge or lasso regression, Principal Component Analysis, or regression trees.

References

[1] J. V. Haxby et al., *Distributed and overlapping representations of faces and objects in ventral temporal cortex*, Science, 293 (2001), pp. 2425–2430.