Visual Hierarchy based fMRI decoding

Team Members: Hrithik Nambiar, Jundong Hwang, Tanishta Bhattacharya, Youjing Luo.

Abstract

fMRI (Functional magnetic resonance imaging) is a technique widely used for measuring brain activity by changes in blood flow, volume, oxygenation in response (BOLD response) to stimuli. In this study, we develop a *decoding* model to predict the class label of an image stimuli shown, using the fMRI activation pattern and the region of interest (ROI) tags of the voxels. This helps us to establish a relationship between the class of stimuli shown and the fMRI activation pattern associated with it.We hypothesise that the fMRI response is a better representation for classifying the stimulus as compared to the image itself in case of small datasets .The dataset that was used is the Kay and Gallant Dataset which composed of 1750 images and their corresponding BOLD response. A preliminary data analysis mentioned the number of images for each class varying differently resulting in class imbalance. To make classification easier, the images were divided into 2 classes - Animal and Artifact. Some problems were that the labels used for the classification were not the true labels but obtained from a model trained on ImageNet. This could lead to errors in the study. The small dataset also led to overfitting during training which we tried to minimise as much as possible.

To investigate our main hypothesis, we designed a deep neural network which aims to predict the class labels of images using as input the BOLD response to the image stimulus. Further, to mimic the hierarchical visual processing system observed in animals, we decided to process the fmri response from different ROI at different stages in the neural network in contrast to processing the fMRI data together.

As we expected, the BOLD response is a better representation of the stimuli for classifying the image stimulus. We conclude that our DNN model using the BOLD response data was a better learner in the classification task compared to ResNet architecture on the images. Hierarchical processing in the neural network, of the fMRI inputs from different ROI in the brain is observed to be a better learner in the classification task. Further studies can be done to understand the similarity between the BOLD response when objects become more similar. We hypothesize that as the stimuli becomes more related and down the wordnet hierarchical tree, classification tasks can become challenging due to similar fMRI activation patterns.