Brain Decoding models for Visual Brain

Cognitive Science and AI: Assignment 3

March 7, 2025

1 Instructions for submission

Deadline: 16/03/2025

Maximum marks - 100

- You may do the assignment in Jupyter or Colab notebook or a script that executes the code.
- A report should be submitted that includes all the deliverables. Report and code should be included in a folder specified by Roll Number and Name of the student and submitted in Moodle, adhering to the deadline.
- Include the assignment number, your name and roll number in the notebook/script as well for better identity.
- Late submissions are NOT accepted.
- IMPORTANT: Make sure that the assignment that you submit is your own work. Do not copy any part from any source including your friends, seniors. Any breach of this rule could result in serious actions including an F grade in the course.
- Your marks will depend on the correctness / convincing discussion points. In addition, due consideration will be given to the clarity and details of your answers and the legibility and structure of your code.
- Do not copy or plagiarise, if you're caught for plagiarism or copying, penalties are much higher (including an F grade in the course) than simply omitting that question.

2 Objective

This assignment focuses on decoding visual stimuli given brain responses. For extracting feature embeddings from visual stimuli, you can choose any appropriate Deep Neural Network architecture and use these embeddings as target labels (y) to train a decoding model for a given brain responses (X). Figure 1 depicts the decoding process.

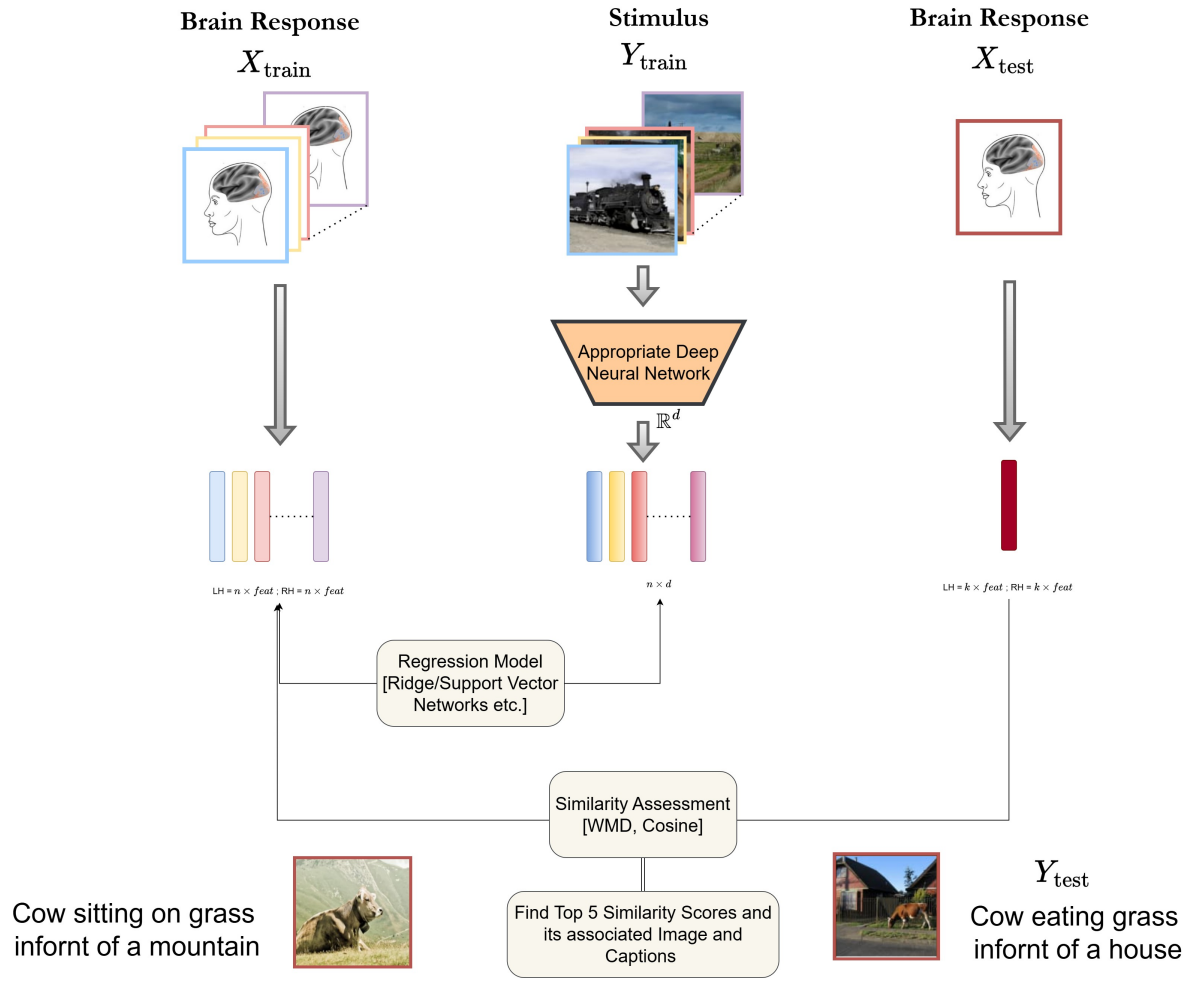

Figure 1: Overview of the assignment. Look into Section 3 for more details.

3 Aims

- Average left and right hemisphere predicted embeddings
- Compare how well the averaged embeddings $\hat{y}_{test}$ closely match from the set of training visual embeddings y_{train} using word mover distance and cosine similarity methods.
- Pick the top 5 closely matched indices and their captions to check the correctness of the decoded image embeddings.
- Compare how well the regression model weights/coefficients from the test data accurately map to each ROI. Manually, compare each ROI and tell us which ROI is could be most responsive for decoding.
- Report top 5 similarity scores, and its corresponding 5 images and 5 captions.
- Bonus points will be given for those who have successfully reconstructed the image.

3.0.1 Learning Outcomes

You will gain experience with decoding pipeline. Also, you will learn how to set up and evaluate predicted visual embeddings to for different brain areas. Develop a critical understanding of

which voxel locations in the brain have maximum predictive capabilities (regression weights) with respect to the ROIs.

4 Dataset

This assignment use dataset from the Natural Scenes Dataset. This dataset is a visual stimuli task-based fMRI dataset where subjects saw static images while fMRI recordings were taken. The dataset contains:

- 8 subjects
- Each subject has fMRI brain responses (left and right hemisphere) and stimuli (visual image) attached to that response.
- Additionally, each image has a caption associated with it which can be retrieved from the COCO image database.
- Whole visual brain responses both left and right hemisphere should be used for decoding process.
- ROI-specific brain responses can be used to compare the top predictive brain vertices (output from regression model) in these ROIs.
  - Early retinotopic visual regions (prf-visualrois): V1v, V1d, V2v, V2d, V3v, V3d, hV4
  - Body-selective regions (floc-bodies): EBA, FBA-1, FBA-2, mTL-bodies
  - Face-selective regions (floc-faces): OFA, FFA-1, FFA-2, mTL-faces, aTL-faces
  - Place-selective regions (floc-places): OPA, PPA, RSC
  - Word-selective regions (floc-words): OWFA, VWFA-1, VWFA-2, mfs-words, mTL-words

5 Deliverables

A complete end-to-end pipeline implementation should be provided in the form of Jupyter Notebook or Google Colab. This notebook should be executable by just one click. While submitting all notebooks should have the outputs rendered (inlined) wherever necessary for a quick evaluation. Only those notebooks that shows the rendered outputs is considered for further evaluation.

A report should discuss in detail, the process of creating a pipeline and end-results + visualizations wherever necessary.