

# Visual image encoding and reconstruction from brain activity

Cognitive Science and AI: Assignment 2

February 17, 2023

## 1 Instructions for submission

Maximum marks - 30

Deadline: 25th Feb 2023

- You may do the assignment in Jupyter or Colab notebook.
- You need to submit a notebook specified by Roll Number roll\_no.ipynb in Moodle before deadline.
- Include the assignment number, your name and roll number in the notebook as well for better identity.
- No late submissions are 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 of answers and output. 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 Objectives

This assignment will be completely based on experimental stimulus images consisted of formed geometric shapes ("square," "small frame," "large frame," "plus," and "X") or alphabet letters ("n," "e," "u," "r," and "o") as shown on Figure 1.

**Visual encoding** 10 marks

Build encoding model that predicts brain activity given experimental stimulus images shown on Figure!1. What are the differences in these encoding patterns in the brain visual areas between geometrical and alphabetical images? In other words, explore top  $R^2$ -squared scores in brain voxels and its correspondence in the brain visual areas. Write a short discussion linking which of the visual cortex regions are recruited when watching shapes and letters. Please use visual cortex mask for this task.

### **Representational Similarity Analysis** 10 marks

Considering the timeseries voxels from these three masks: V1, V4 and visual cortex, plot the RSA matrices for geometrical shapes and alphabetical letters. Discuss the RSA patterns and its similarities across shapes/patterns for V1, V4 and whole visual cortex. The discussion should address why such similarities exists between such shapes/patterns.

Each of the geometrical shape and letter are repeatedly shown in random order. So, fMRI signals that corresponds to similar shapes/letters can be averaged as an input to compute RSA.

### **Visual decoding** 10 marks

Build decoding model that reconstructs stimulus patterns given recorded brain activity. In this task, geometrical and alphabet stimulus patterns should be reconstructed using visual cortex mask. Visualize the decoded brain weights and write a short discussion on your observations.

## **3 Dataset**

The Miyawaki et al. 2008 dataset (Miyawaki et al. 2008).

Stimulus images presented to human subject while recording brain activity (fMRI images).



Figure 1: Snapshot of 10x10 pixel images from figure imaging session where subjects viewed geometric shapes (left) and alphabets (right)

Masks: Visual cortex mask is stored in a key "mask".

All the V1, V4 related masks can be found in a key "mask\_roi"

## **4 Deliverables**

Discussion should be supported by the quantitative visualizations of the outputs wherever necessary for an easier understanding to evaluators.

## **References**

Miyawaki, Y et al. (2008). "Visual image reconstruction from human brain activity using a combination of multiscale local image decoders." In: *Neural Networks* 60.5, pp. 915–929.