

Brain Decoding Using Connectivity Informed Models

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1 Introduction, and Problem definition



Outline

- 1 Introduction, and Problem definition
- 2 Background and Related Work



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- 3 Method
 - Major Perspective
 - Graph Neural Networks
 - Dataset



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- 5 References

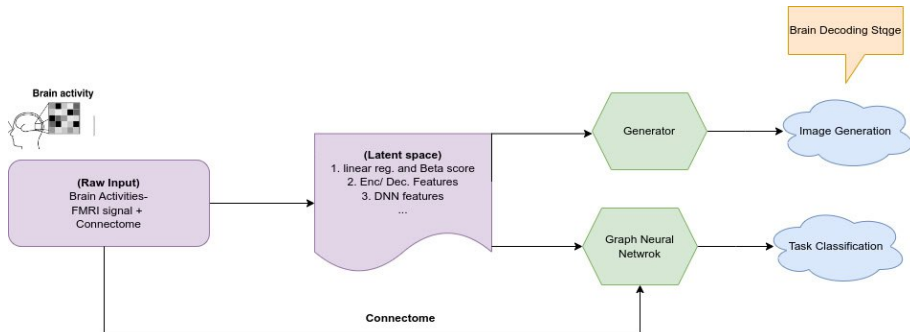


What is Brain Decoding?

- Reconstruction of sensory and other stimuli from information that has already been encoded and represented in the brain by networks of neurons [1]. For example: Image generation, task classification, ...



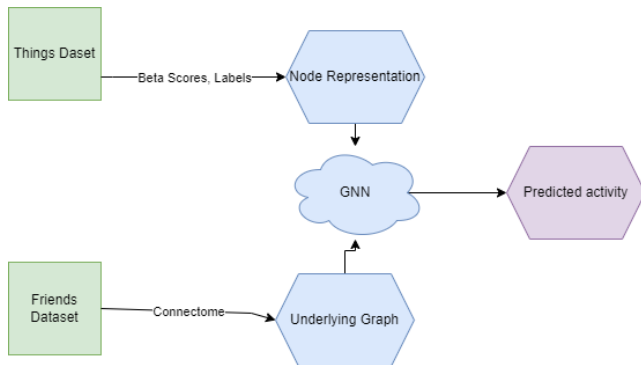
Background and Related Work



Major Perspective

Problem Definition: Stimuli Classification based on the Graph Neural Network.

- Input: Brain activities and β scores extracted from Voxel FMRI.
- Output: Image Stimuli classification

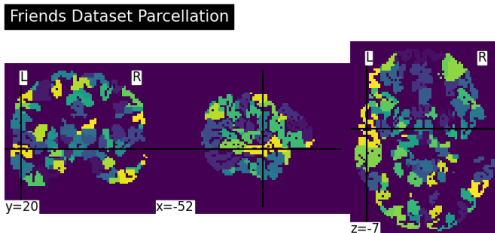
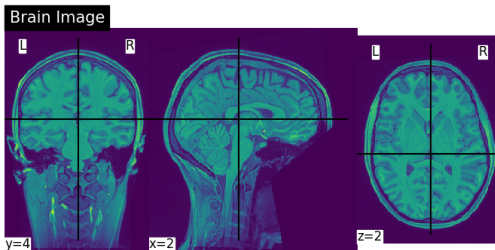


- **Layer Expression:** $H^{l+1} = \sigma(A.H^l.\Theta)$, $H^0 = X$, H is the layer representation, and A is the Adj. Matrix. Θ is the learnable parameters.
- **ChebNet: suggested in tutorial [2]**
 $3x[\text{ChebConv}(\cdot) + \text{Relue}(\cdot)] + 3x[\text{Linear}(\cdot) + \text{Relue}(\cdot)] + \text{SoftMax}(\cdot)$



Dataset

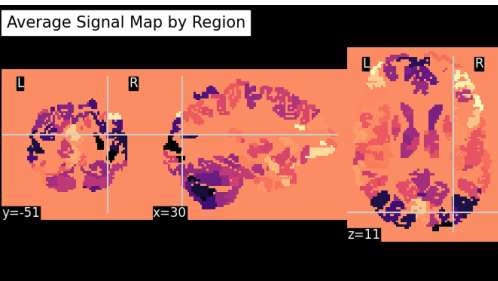
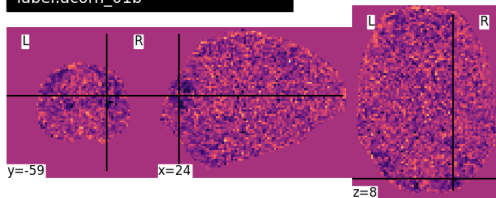
- Friends-Dataset To extract Connectomes:



Dataset

- Things-Dataset (To project Beta scores to each parcel):

Beta Scores Mapped to Brain Atlas
label:acorn_01b



Dataset: Highlevel-Categories

- Highlevel-Categories (labels) things Dataset:

Top 8 labels and their counts:

animal: 336

food: 294

vegetable: 144

fruit: 132

clothing: 126

tool: 102

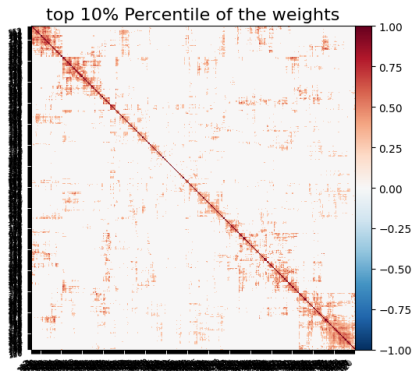
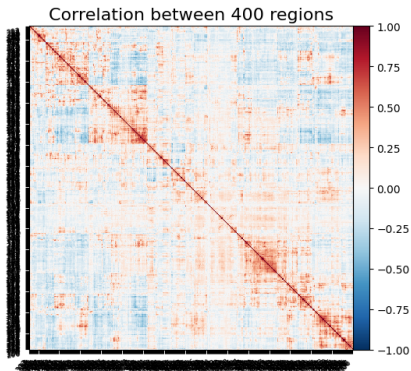
sports equipment: 96

insect: 84



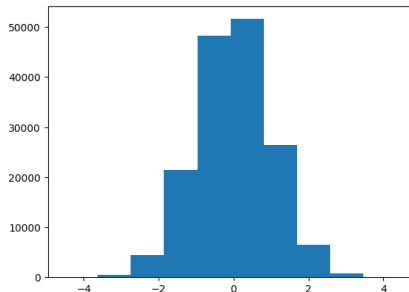
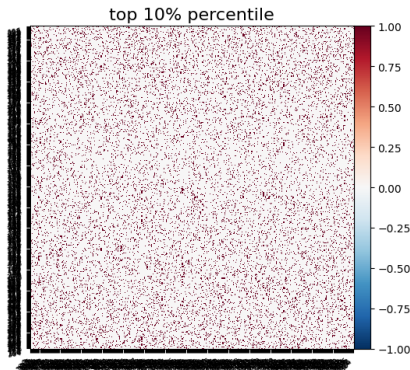
Connectom Representation

- Friends Dataset:



Random Graph

- weights $N(0, 1)$:



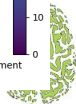
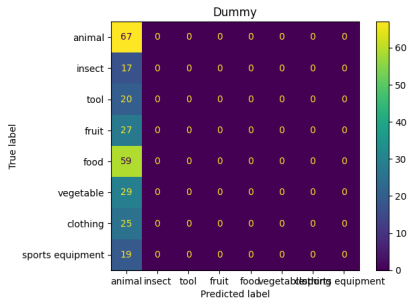
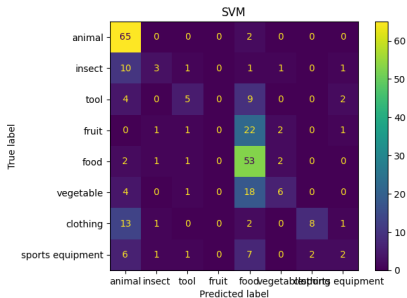
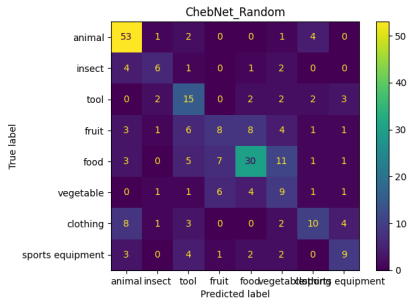
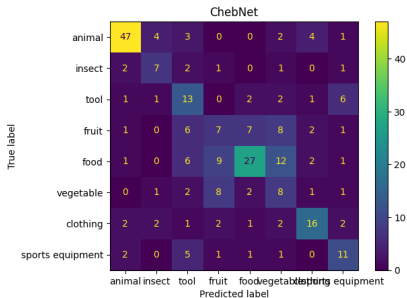
Results: Performance Metrics for Different Methods

Method	F1 Score (weighted)	Accuracy
Dummy Classifier	0.1034	0.2548
SVM	0.4603	0.5399
Chebnet	0.5280	0.5170
Chebnet (with Random Graph)	0.5252	0.5320

Table: F1 Score and Accuracy for Different Methods

- Graph Effect
- Generalized classes





Tools and Deliverables

- Tools

- model training: `torch_geometric`
- result visualization and pre processing: `nilearn`, `matplotlib`, `numpy`, `pandas`

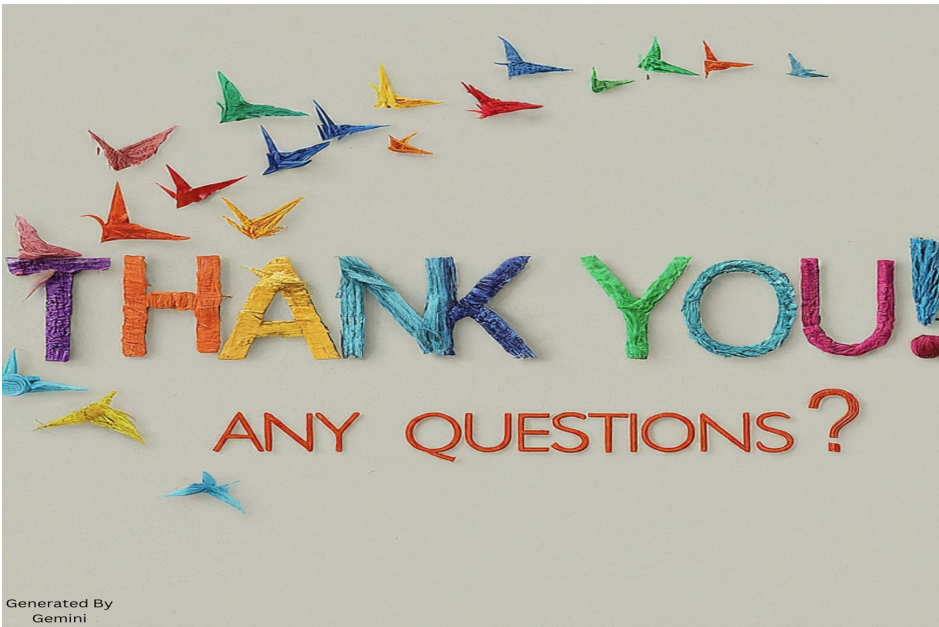
- Deliverables

- Jupyter Book (online):
<https://aarian.github.io/BrainDecoding/intro.html>
- Jupyter notebook for the experiments:
<https://github.com/Aarian/BrainDecoding>



References I

- [1] K. O. Johnson, "Neural coding," *Neuron*, vol. 26, no. 3, pp. 563–566, 2000, ISSN: 0896-6273. DOI: [https://doi.org/10.1016/S0896-6273\(00\)81193-9](https://doi.org/10.1016/S0896-6273(00)81193-9). [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0896627300811939>.
- [2] main-educational, *Brain encoding and decoding: Graph construction*, https://github.com/main-educational/brain_encoding_decoding/blob/main/src/graph_construction.py, Accessed: 2024-05-30, 2024.



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