Prediction of Age and Biological Sex using Spatial-Temporal Graph CNN on fMRI Scans

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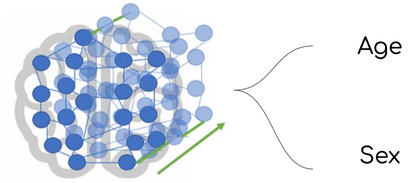
Introduction

- The Human Connectome Project aims to build a complete functional and structural map of the human brain
- We use their fMRI and structural MRI brain scans to predict sex and age
- We use a novel approach by employing ST-GCN
- This research project can be used to discover and improve understanding of sex-linked and age-related neurological diseases

Problem

- Given a 4D brain scan, classify age and sex of a patient
- Regression on age, binary classification of age (old, young adult) and sex (male, female)



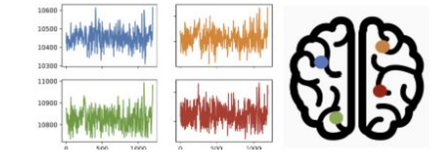
4D Brain Scan

- ST-GCN Test Accuracies
  - Age : 63% , Sex: 78%

Dataset

- Original input data
  - fMRI scans from 1108 healthy individuals, 603 female, 505 male
  - Each file is of 200 brain regions of 1,200 timesteps
- Data augmentation
  - Each file was fragmented into 100 time steps, which resulted in 12 fragments
  - Coarser brain sampling (22 brain regions instead of 200)
  - This resulted in 13,082 samples

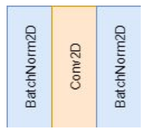
Feature Mapping



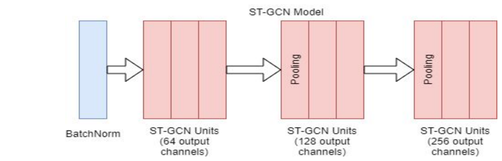
- Brain regions act as nodes in the graph. Correlation between regions act as edges
- Adjacency matrix captures correlations of brain region across timesteps
- Feature mapping is computed by using

$$f_{out} = D^{-1/2}(A+I)D^{-1/2}f_{in}W$$

ST-GCN Unit and Model



ST-GCN Unit
- ReLU Activation
- No dropout

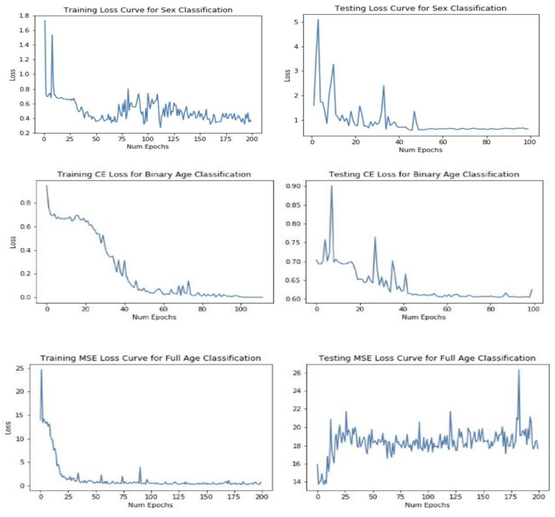


- Final layer predictions computed with and without Softmax for binary and real-number outputs

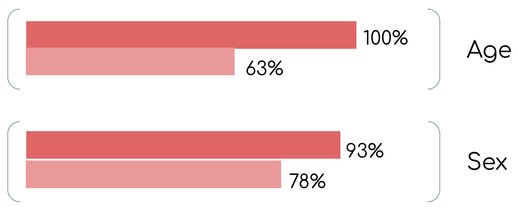
$$\mathcal{L}(y_i, \hat{y}_i) = -\frac{1}{m}\sum_{i=1}^{m} y_i log(\hat{y}_i) + (1-y_i)log(1-\hat{y}_i)$$ CE Loss

$$\mathcal{L}(y_i, \hat{y}_i) = \frac{1}{m}\sum_{i=1}^{m}(y_i - \hat{y}_i)^2$$ MSE Loss

Results

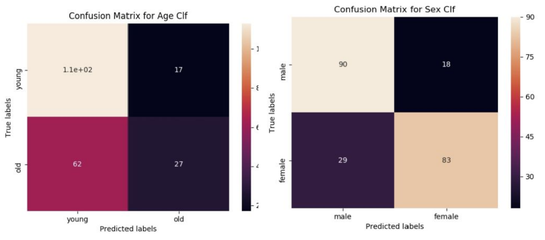


Accuracies (Train/Test)



Discussion

	Precision	Recall	F1 Score
Age	0.6457	0.8692	0.741
Sex	0.7563	0.833	0.793



- Model show similar accuracies for male and female brains but predicted male more often
- Age classification accuracy lower, but model was still able to distinguish age bins

Future Work

- Large gap in train/test accuracies suggest we use dropout and weight regularization
- Analyze subject level prediction instead of sample level prediction for better accuracies

Notable References

For full list please checkout github.com/ericksiavichay/cs230-final-project

1. Kipf, T.N., Welling, M.: Semi-Supervised Classification with Graph Convolutional Network https://arxiv.org/abs/1609.02907
2. Li, X., et al: Graph Neural Network for Interpreting Task-fMRI Biomarkers https://arxiv.org/abs/1907.01661
3. Yan, S., Xiong, Y., Lin, D.: Spatial Temporal Graph Convolutional Networks (ST-GCN) for Skeleton-Based Action Recognition in PyTorch https://github.com/yysijie/st-gcn