Novel Neuro Behavioral Analysis

Justin Chen and Jonathan Wang

RUTGERS
Aresty Research Center
for Undergraduates

Abstract

fMRI-based functional connectivity has become a major neuroscience tool in brain-behavioral relationship analyses. However, based on a recent study, individual functional connectivity exhibited a poor test-retest reliability (ICC=0.29). In this project, we are developing a new approach for generating functional connectivity maps and examining it for its improved test-retest reliability. To avoid potential high reliability at the cost of validity, we are also examining whether using our functional connectivity maps as predictors will result in better prediction accuracy and improved inferences in brain behavioral relationship analyses. Our research aims to establish neuroanatomical biomarkers of aging processes that may provide insight into how these diseases interact with the ageing process. By utilizing advanced machine learning models, our goal is to extend previous fMRI based brain age prediction methods, along with incorporating information from multimodal brain image data to make accurate predictions on brain age while also being able to identify the key factors in development. We will be extracting ROI-based morphological measurements from preprocessed sMRI data and extracting function brain features from fMRI data to be used for brain-behavior analyses and as potential predictors of brain age.

Background

•fMRI brain scans - Functional magnetic resonance imaging measuring the changes in blood flow that take place in an active part of the brain, we use 36 scan sessions from over 1000 subjects.

•Functional Connectivity - network of relationships between different nodes of the brain

•Test Retest reliability - statistical method of correlating different brain scan networks together and identifying the brain scan with the highest correlation to see if the subject matches.

•Wavelet transformation - a form of data compression that represents transient signals well

•Neural Networks - advanced machine learning algorithm consisting of many nodes and connections that simulates the architecture of a brain

We propose a novel method of wavelet transforming brain functional connectivity in order to increase test retest reliability as well as prediction accuracy of subject age using a neural network.

References

Glasser, M., Coalson, T., Robinson, E. *et al.* A multi-modal parcellation of human cerebral cortex. *Nature* 536, 171–178 (2016). https://doi.org/10.1038/nature18933

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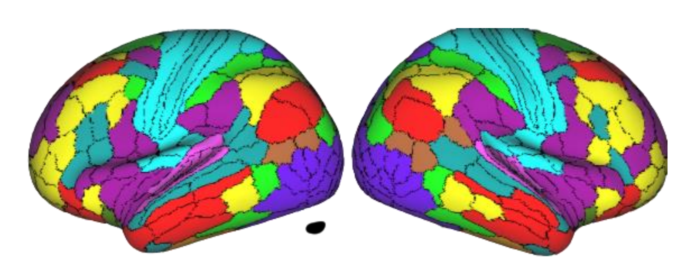
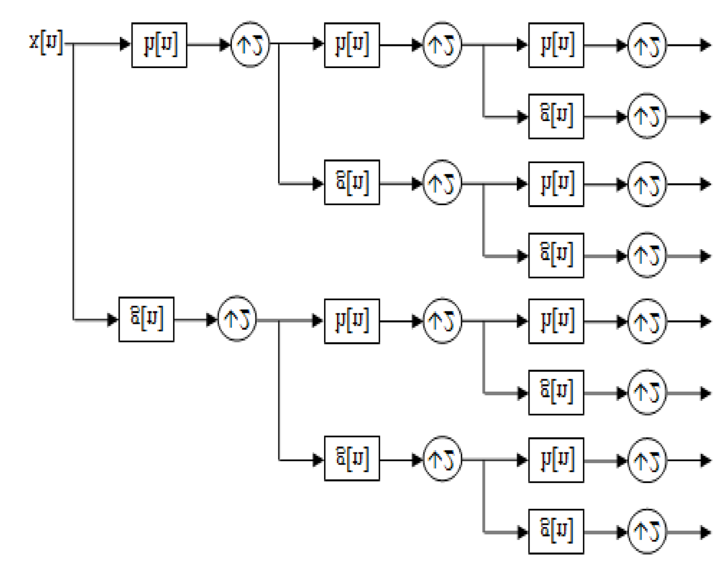
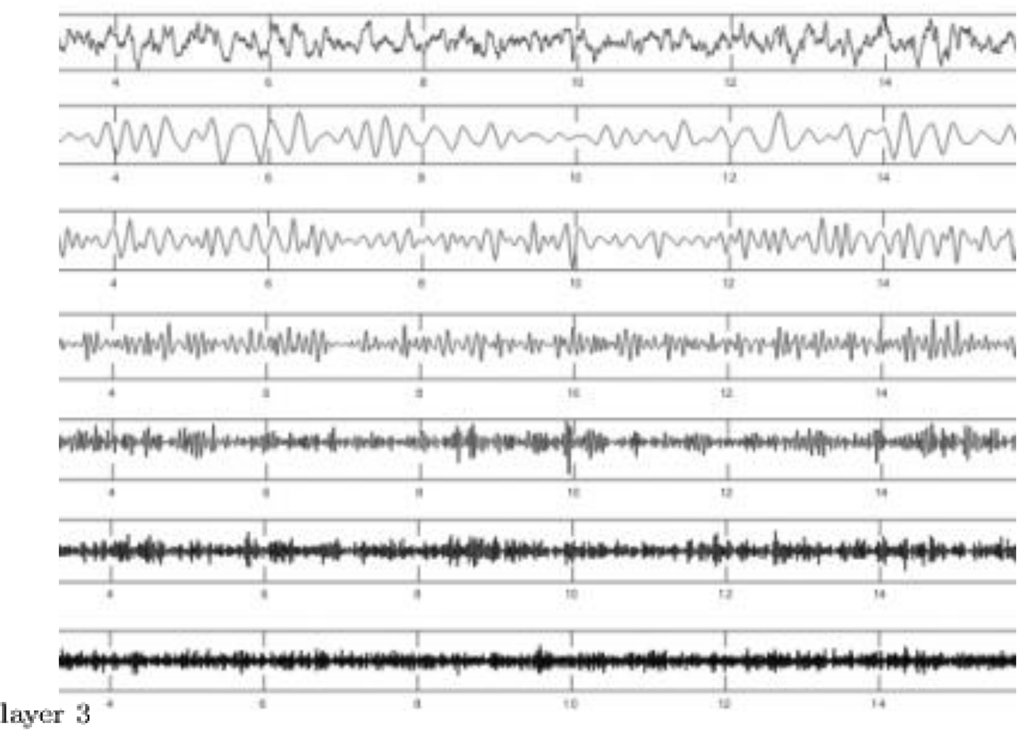
Methods and Materials

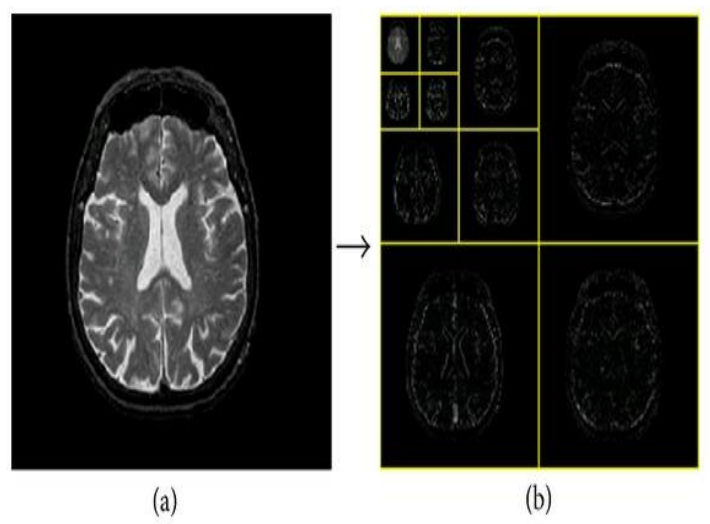


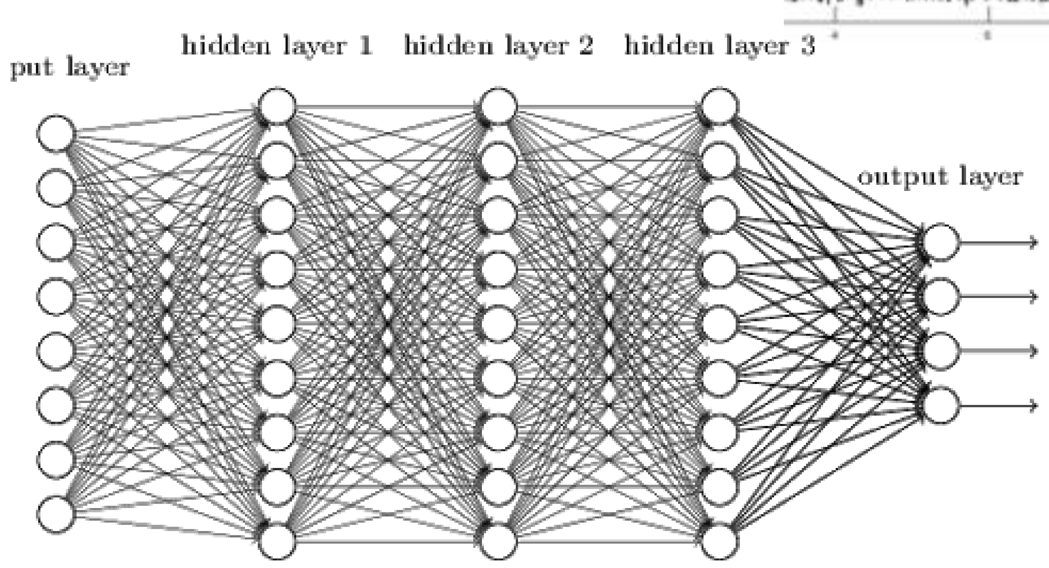
1113 subjects

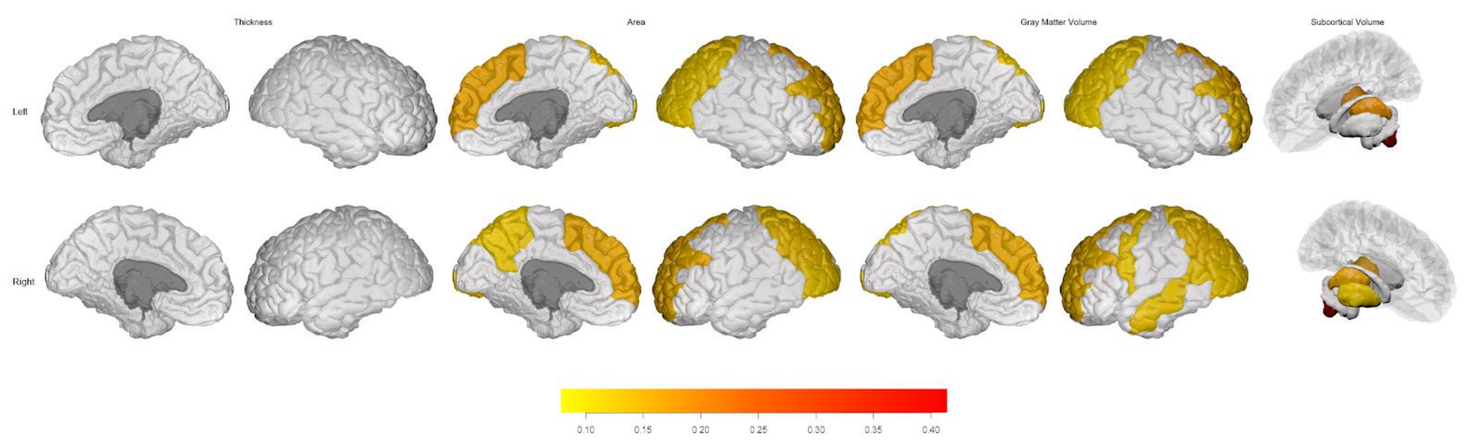




First the dataset is extracted minimally preprocessed and fit to our 718 region brain atlas (Cole-Anticevic) and 360 region brain atlas (Multi-modal). The dataset consists of 1113 subjects with resting state and task brain scans. Second we apply the wavelet transform to decompose our functional connectivities into macro and micro details. Third we calculated test retest reliability with Pearson correlation at the optimal wavelet level for each brain scan pairing. Lastly we developed a predictive neural networks in order to make predictions on age and alcohol and substance abuse disorders. We then analyzed these models to find key factors that contribute to the development of these disorders.







Results

Test Retest reliability exhibited a 120% increase over traditional methods

Results with prediction accuracy were consistent with the levels of noise within the data set. We reported an average MSE of 3.2 predicting on a testing dataset.

We are still currently trying to develop even more accurate models by minimizing the effects of random noise in the dataset on the prediction accuracy.

Wavelet micro detail decomposition outperforms traditional and other wavelet approaches for task based functional connectivity test retest reliability at optimal decomposition level (3)

Using machine learning models for brain feature prediction and variable analysis shows promising results but requires a lot more tuning in order to maximize their effectiveness.

Future Direction

Increasing test-retest reliability

There is still a significant margin of improvement for task based fMRI test retest reliability where it is only around 0.55 currently. Increasing test retest reliability would increase confidence in using task fMRI brain scans in medical prognosis and diagnosis.

Increasing prediction accuracy

We still have a lot of tuning we can do on preprocessing the datasets in order to minimize noise, as well as tuning hyperparameters for our various models. Additionally, we are looking at different variations of our current models such as iterative random forests and different styles of neural networks.

Acknowledgements

Special Thanks to Dr Yihong Zhao for the guidance and direction on this project Thanks also to the Aresty program.

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