Early diagnosis of Alzheimer's disease using multiple brain parcellation ensemble machine learning with resting-state fMRI

Dilip Rajeswari [1], Sunil Vasu Kalmady [1], Rimjhim Agrawal [1]

[1] R&D, Brainsight Technology Private Limited, 6th Floor, No. 22 (KSR), Salarpuria Towers - 1, Hosur Road, Koramangala, Bangalore - 560095, India

Alzheimer's, characterized by initial cognitive decline and memory impairment, accounts for up to 80% of all dementia cases [1]. The cost of illness of dementia was estimated, on a global scale, to be $818 billion in 2015 alone [2]. Early diagnosis will help significantly decrease this cost [3]. Previous research has shown statistical changes in Resting-state functional MRI (RS-fMRI) to indicate pathophysiology of Alzheimer's disease (AD), and help in the early diagnosis of AD [4]. This paper uses an ensemble approach to arrive at better prediction accuracy and interpretable models for AD.

Structural MRI and RS-fMRI of 111 individuals with AD and 117 age- and sex-matched healthy controls (HC) from Open Access Series of Imaging Studies 3 were used [5]. Alternative low-frequency fluctuation (ALFF) [6] from 4 different brain parcellation schemes – Automated Anatomical labeling (AAL, 116 ROIs) [7], dosenbach (160 ROIs) [8], desikan (148 ROIs) [9], and power (264 ROIs) [10]. The machine learning model was given ROI features from all four of the chosen parcellations and concatenated, totaling the feature count to 688 (116+264+148+160 ROIs).

Two Machine learning models were used on the new 688 ROI features to classify between AD and HC, one using Support vector machine (SVM) (82.129 +/- 5.369 error), and the other using Linear regression model (LR) (81.579 +/- 5.019 error), both with grid-search for hyperparameter optimization, 10-fold cross validation, and 5 shuffled iterations. An additional stacked model was used on a combined ensemble of the two to arrive at a stacked accuracy of 82.719 +/- 5.229 error. This is better than a chance accuracy of 51.51%, and than obtained by running LR, SVM, and the corresponding stacked model on one parcellation (Figure 1).

Conclusion: Concatenating features from multiple parcellations together gives better performance accuracy in classifying AD vs HC when compared with one parcellation. This is more optimal for early diagnosis because regional brain activity of different parcellation ROIs gives an BOLD averages at varying levels of granular detail. So, this approach lets us use top regional areas from multiple ROIs for classification, and help in interpreting brain regions contributing to the pathology of early AD. This will further our goal of using RS-fMRI to better predict AD neurophysiology, and facilitate earlier and preventive intervention.

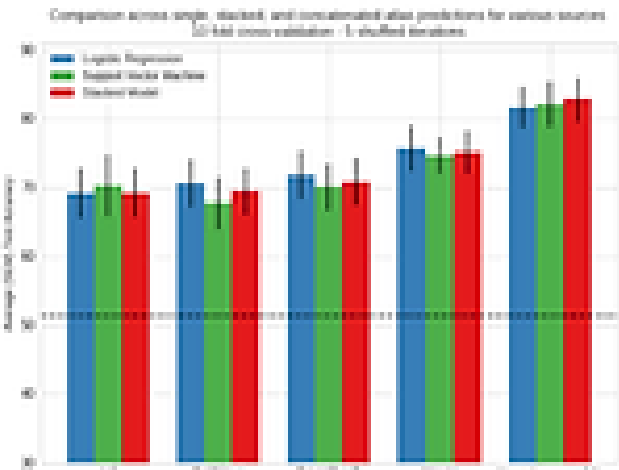

Figure 1: By comparing the different models, we can see that the 'concat_ensemble' (the model with 688 concatenated features) performs better than all the other single and single-stacked models. The dotted line represents the 'major class baseline accuracy.' SEM refers to the standard error of the mean.