CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Pravin Ravishanker

Project Number

S1223

Project Title

ALZCan: Predicting Future Onset of Alzheimer's Using Gender, Genetics, Cognitive Tests, CSF Biomarkers, and Neuroimaging

Abstract

Objectives/Goals

Since no preventive methods or precise diagnostic tests exist for Alzheimer's disease, I hypothesized that one can create an accurate diagnostic/ prognostic software tool for early detection of Alzheimer's using resting-state functional MRI brain imaging (multi-voxel pattern analyses), genetic single nucleotide polymorphism data, cerebrospinal fluid (CSF) concentrations, demographic information, and psychometric tests.

Methods/Materials

Using "open-source R project" and data from the Alzheimer's Disease Neuroimaging Initiative (ADNI), an ongoing, longitudinal, global effort tracking clinical/imaging AD biomarkers, I examined 678 4D NIfTI fMRI scans and 56847 observations of 1722 individuals across three cohorts (Healthy-Controls (HC), Mild-Cognitive-Impairment (MCI), Alzheimer's (AD)). Independent Component Analysis on fMRI scans yielded graph structures of connectivity between different brain networks.

For diagnosis: 4 Support Vector Machines and 6 Gradient Boosting Machines were trained 10 times each for fMRI, genetic, CSF biomarker, and cognitive data.

For prognosis: 3 linear regression models predicted cognitive scores 6 to 60 months into the future. Forecasted cognitive scores and demographic information were used for prognosis.

Results

ALZCan had an overall 81.82% diagnostic accuracy, with high specificity for diagnosing AD and HC groups (91.7% and 81.6%) and high precision for MCI (83.3%).

With 97.5% CI, prognostic accuracy 6, 12, and 18 months in future was 75.4%, 68.6%, and 55.6% respectively. MCI prognostic accuracy was above 97%, and specificity for AD and HC was above 99%. AD patients showed significantly lower transitivity and average path length between functional brain networks. Cognitive tests (ADAS-Cog) and biomarkers like beta amyloid exerted high influence on predictive accuracy. I confirmed my previous year's findings that gender has a higher relative influence than genetic risk factors on AD diagnosis.

Conclusions/Discussion

This study engineered a novel neuroimaging feature selection method by using machine learning and graph-theoretic functional network connectivity properties for diagnosis / prognosis of disease states. I examined relative influence and predictive power of multiple biomarkers in Alzheimer's. This analytical tool elucidates Alzheimer's underlying pathology and known etiology and is capable of predicting the future onset of the disease with significant accuracy.

Summary Statement

By analyzing cognitive scores, functional connectivity in resting state fMRI, cerebrospinal fluid biomarkers, genetic data, and demographic information, I built a novel analytical tool for accurate diagnosis/ prognosis of Alzheimer's.

Help Received

My family, my teachers, and Mr. Wong for encouragement, my mom Shanthi Pichai for mentoring, Dr. Ariana Anderson (UCLA School of Medicine) for guidance on functional network connectivity based classification, and ADNI and its investigators for valuable data.