UR-1195 Using Machine Learning to Diagnose Alzheimer’s

Abstract

Early detection of Alzheimer’s disease (AD) remains a significant clinical challenge, as the changes associated with cognitive decline are often subtle and difficult to identify through visual assessment alone. This study investigates modern machine learning methodologies to improve the prediction of cognitive impairment using volumetric MRI–derived region-of-interest (ROI) features. We constructed three binary classifiers [NC vs. AD, MCI vs. AD, and NC vs. MCI] and evaluated various algorithms, including logistic regression, random forests, neural networks, and support vector machines (SVMs). Using measurements generated from eight anatomical brain templates, our models learned patterns indicative of normal cognition, mild cognitive impairment, and Alzheimer’s disease. Among all tested approaches, the radial basis function (RBF) SVM consistently achieved the highest performance, reaching accuracies of approximately 70–80% depending on the classification task. We discuss the implications of this model’s dominance for future clinical applications and the continued development of machine learning–driven diagnostic tools.

Introduction

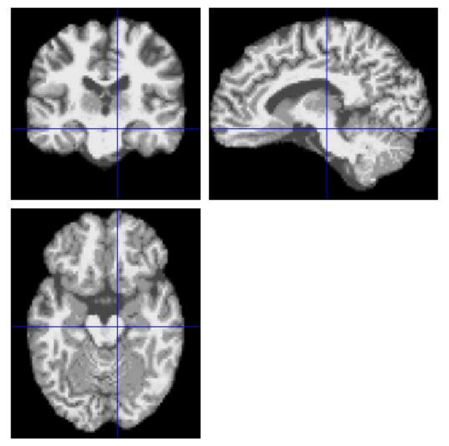
Alzheimer's Disease is a neurodegenerative disorder that is responsible for between 60%-80% of dementia cases worldwide. The changes in which Alzheimer’s disease presents in the brain can often be subtle; hence it’s difficult to diagnose early enough to significantly stifle advanced development of the disease. Human doctors often struggle with noticing the extremely fine details which can be early signals of AD, however recent advancements in Machine Learning Technology have allowed computer scientists to engage in large scale data processing at a scale never seen before. This begs the question; how can we use these new advancements in technology to further scientific discovery in areas which human comprehension has struggled?

Using machine learning technology, we hope to train a model to identify the differences between patients who have a normal cognitive (NC), mild cognitive impairment (MCI), and patients who present with Alzheimer's Disease (AD). We hope to do this via the in-depth analysis of volumetric Region of Interest (ROI) data.

Research Questions

Is there a way to diagnose Alzheimer’s Disease in its earlier stages? Can we predict the disease before it starts? Is there a way to catch the early signs that doctors might miss?

Materials and Methods



MATLAB is an integrated development environment purpose built for large scale data processing. We used this and a variety of external libraries to process hundreds of MRI image files to give us our ROI data.

More specifically, we used 8 unique templates of the human brain to generate 914 volumetric measurements for each individual part of the brain.

Fig 1. Example MRI images

We utilized this volumetric ROI data to train three binary classifiers [NC v. AD, MCI v. AD, NC v. MCI]. These classifiers would each learn to recognize patterns in each brain state and decide the likelihood that a patient was NC, MCI, or AD.

We tested various different types of Machine Learning Algorithms for these classifiers. Mainly Logistic Regression (LR), Supervised Vector Machines (SVM), RandomForest Models (RF), and a custom Neural Network (NN). Each of these technologies have different strategies for recognizing patterns which all have a variety of different statistical outcomes.

Results

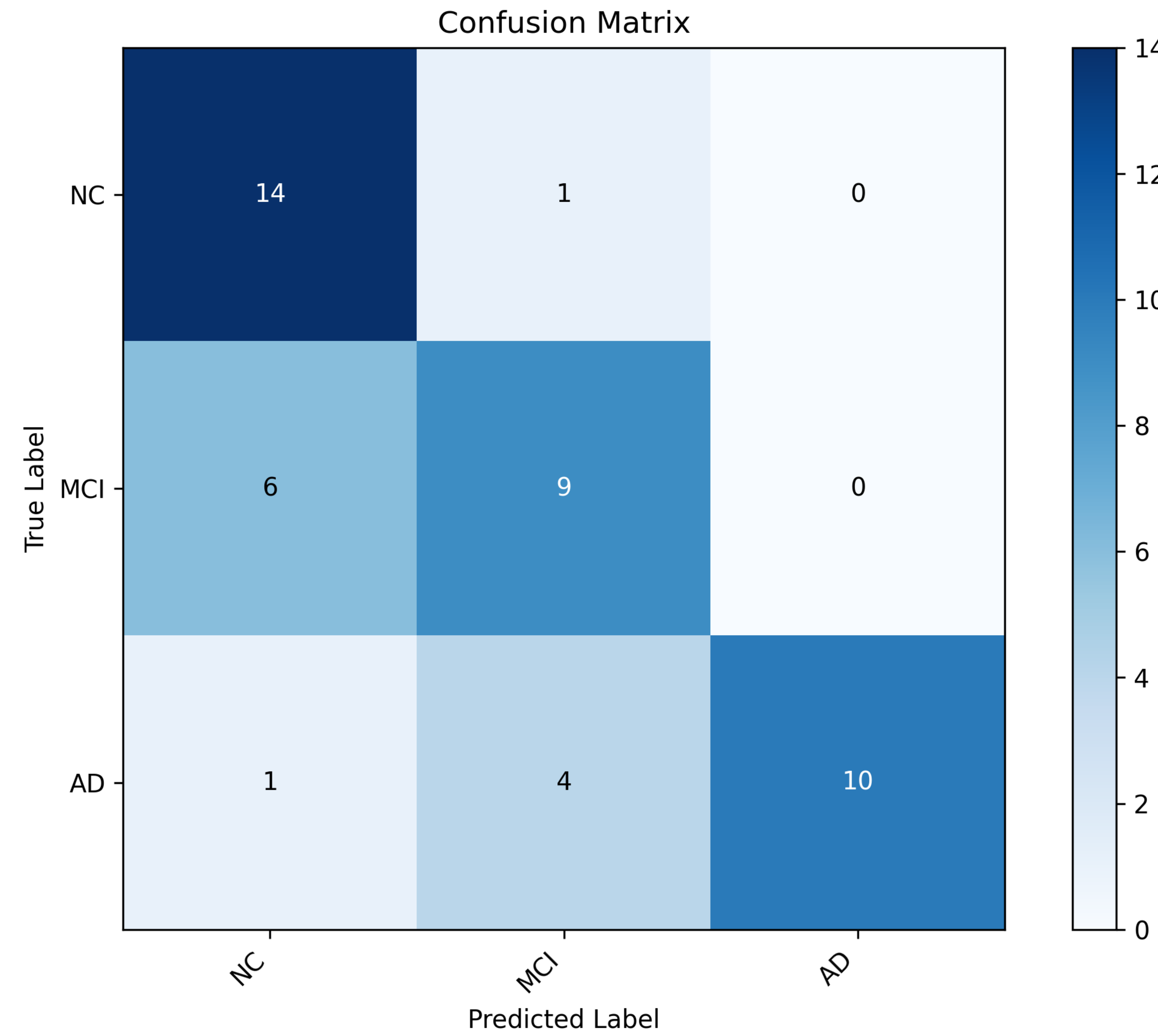


Fig 2: The confusion matrix of the model

Comparison	Acc_Mean	AUC_Mean	Sensitivity_Mean	Specificity_Mean	F1_Mean
NC vs MCI	0.715306122	0.763043025	0.44189975	0.901397994	0.553754446
NC vs AD	0.832888528	0.898536595	0.78686614	0.874957568	0.815825077
MCI vs AD	0.694190241	0.754026275	0.865701201	0.469053151	0.763489782

Table 1: Performance analysis of binary models

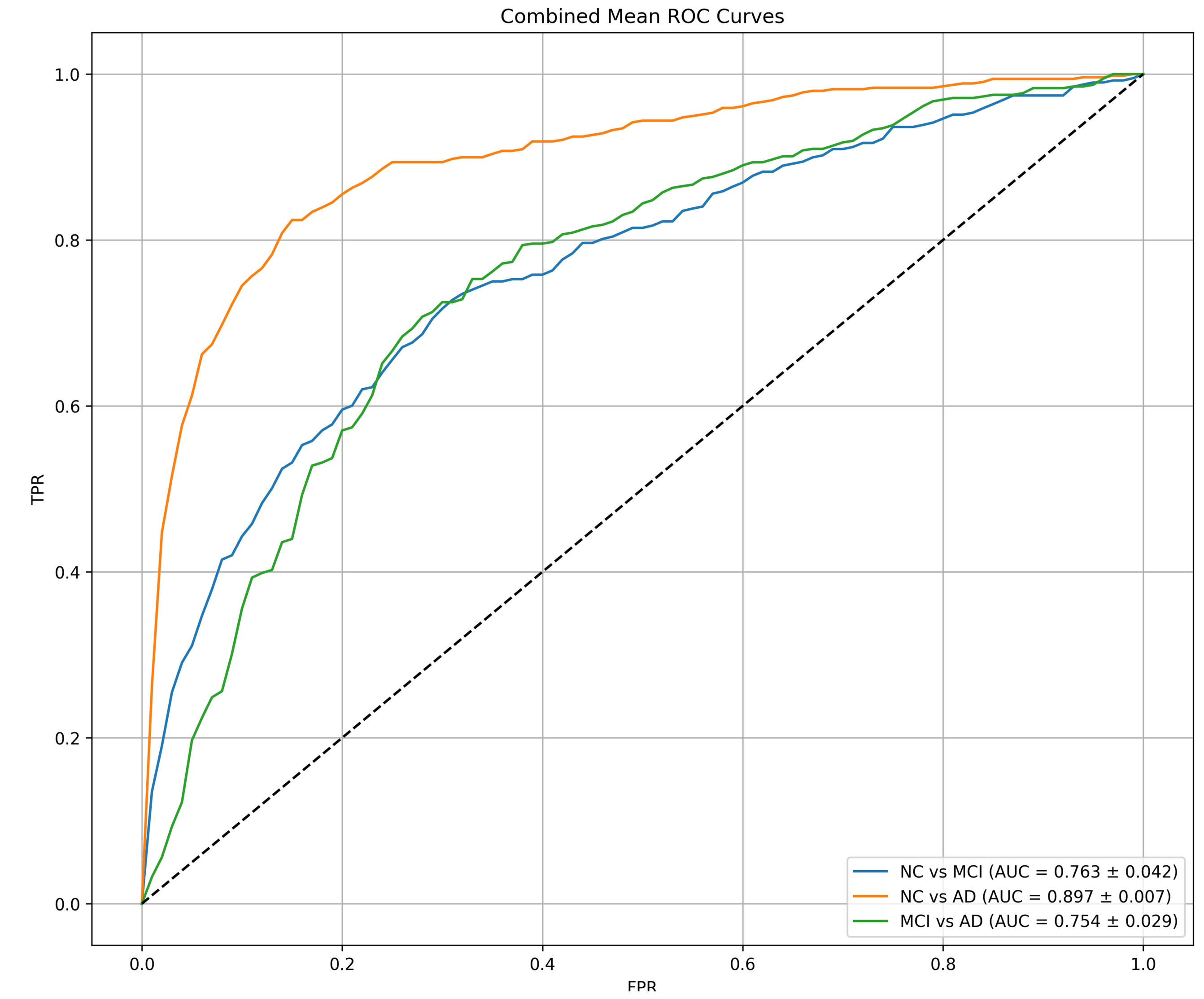


Fig 3: ROC curve for each binary model

Conclusions

At the start of this project, we intended on using a multiclass deep-learning classifier. After doing some research and consulting with our advisors, we determined that three binary classifiers would work better.

Through our research and testing, we concluded that a SVM model with a radial basis function (RBF) was able to diagnose patients with MCI and AD through data from their MRI images with 70-80% accuracy. With this technology, we hope that doctors and medical professionals will be able to catch the disease much earlier on, improving treatment response time and patient prognosis. While there is still some difficulty differentiating between MCI and AD, our technology will help guide doctors to take second looks or ask for second opinions before determining a final diagnosis.

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Contact Information

Julia Johnson’s Email: jjoh1175@students.kennesaw.edu
Jordan Rainford's Email: jrainfor@students.kennesaw.edu

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Website

KENNESAW STATE UNIVERSITY
COLLEGE OF COMPUTING AND SOFTWARE ENGINEERING

Julia Johnson, Jordan Rainford
Dr. Chen Zhao, Prof. Sharon Perry