Alzheimer’s Disease Diagnosis and Progression Level Tracking Using MRI Data

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Introduction

Alzheimer’s disease progression is challenging to measure, with current tools lacking sensitivity, especially in early stages. Literature highlights benefits of timely diagnosis but notes diagnostic limitations and variability in biomarkers. The research gap lies in developing more sensitive, integrated clinical and functional measures for early and accurate Alzheimer’s progression assessment

Motivation

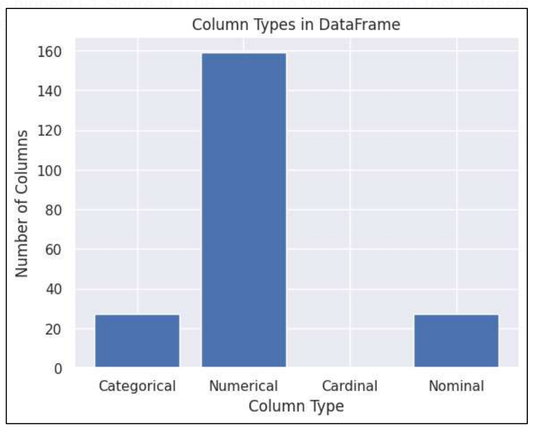
Motivated by the global health crisis of Alzheimer's, this project aims to develop accurate, interpretable machine learning models using MRI data. Early and precise prediction of AD progression can significantly improve patient care and reduce healthcare burdens, supporting SDG 3.

Scope of the Project

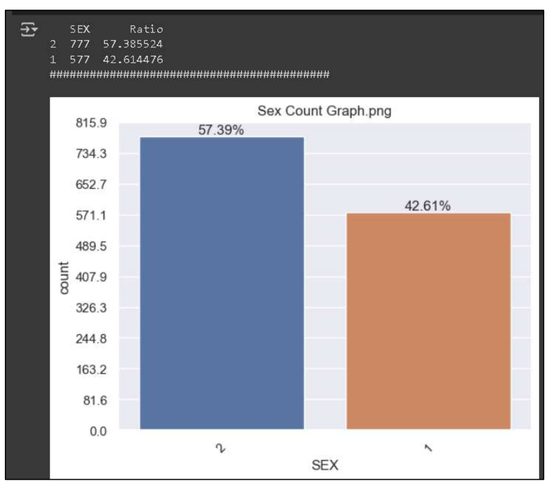
This project's scope includes developing machine learning models for accurate Alzheimer's Disease progression prediction using MRI and clinical data. It encompasses feature engineering, model selection (CatBoost, Random Forest,LightGBM etc.), and performance evaluation via F1-score.

The interpretable model aims to identify key factors driving AD, potentially improving early diagnosis, personalized treatment, and healthcare management.

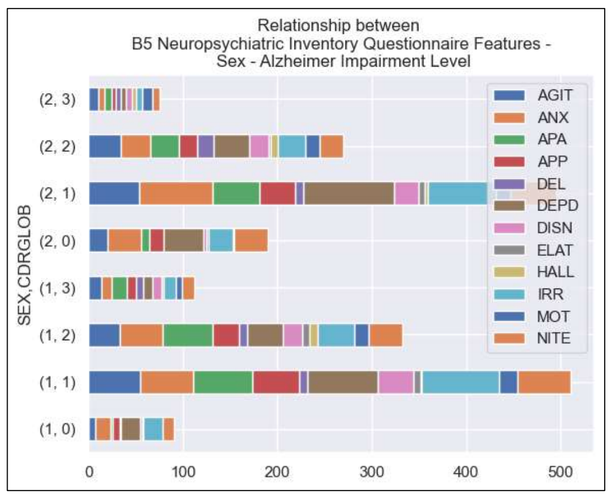
Methodology



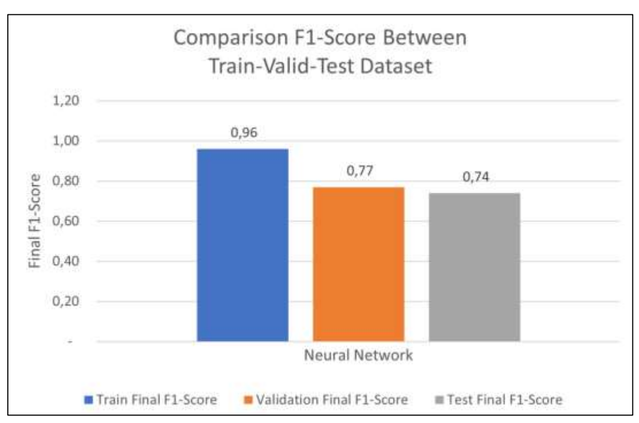
In the model phase, categorical, numerical, cardinal, and nominal columns are determined to approach all kinds of data more accurately. A total of 27 categorical features, 159 numerical features, and 27 nominal features are determined



The data reveals a gender disparity with more male patients. A significant portion (87%+) share characteristics like living alone and no history of major health issues. Certain factors strongly correlate with severe Alzheimer's, including complete dependency, institutional care, eating disorders, nighttime behavior changes, motor issues, irritability, apathy, anxiety, depression, hallucinations, and drug use. These insights highlight key factors linked to AD progression.

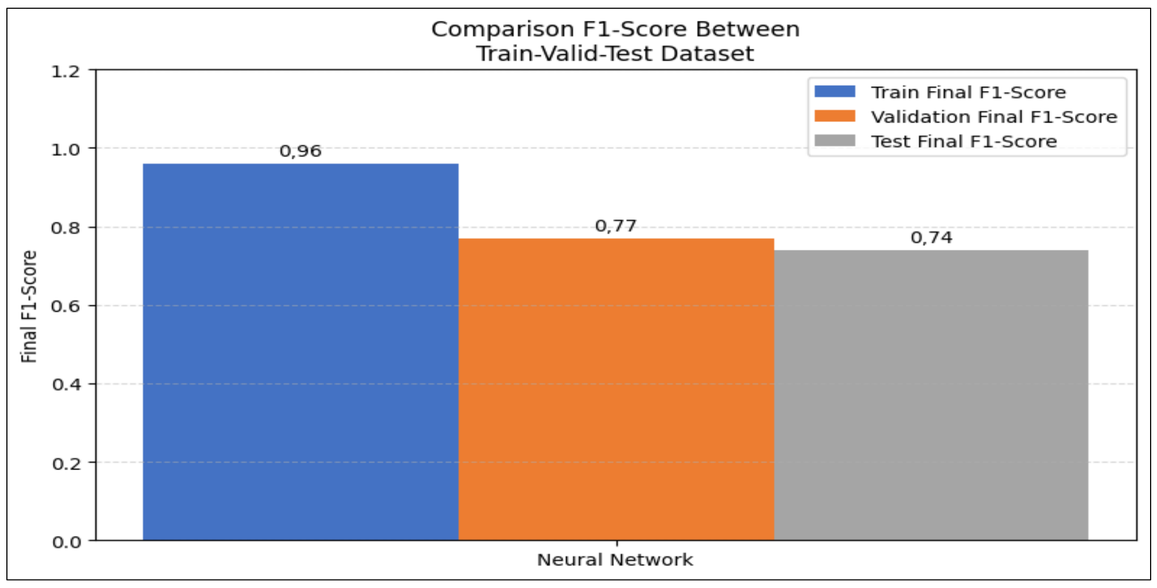


The result from here is:- Aggression, depression, anxiety disorder and irritability in the last month affect the results as questionable impairment in both male and female individuals. (2, 1) (1, 1

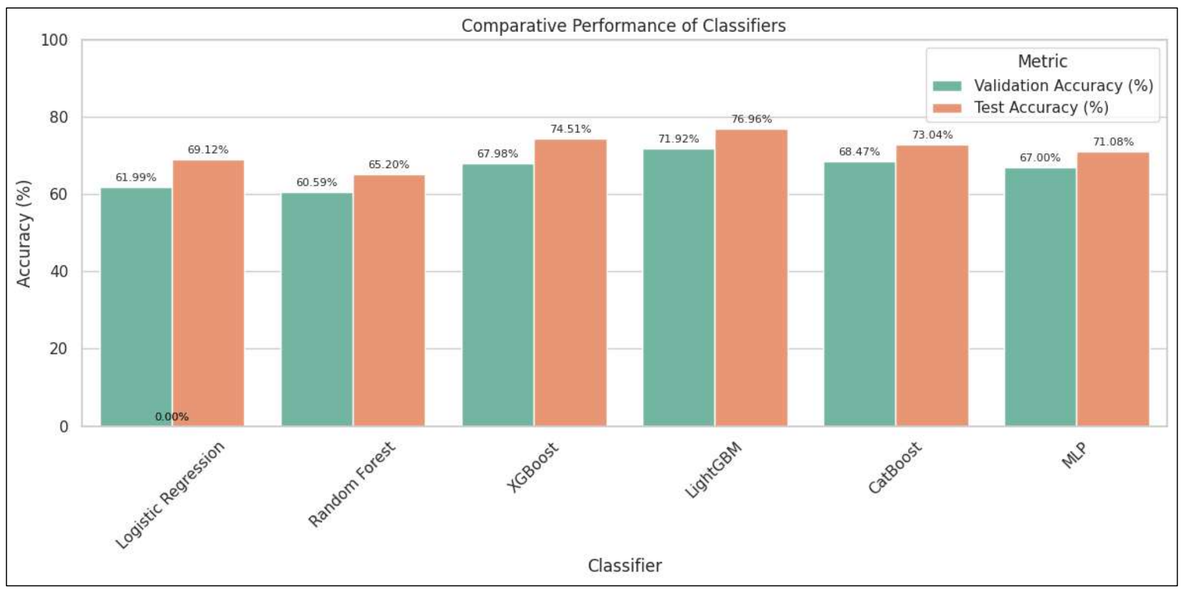


The bar chart compares the Final F1-Score across three datasets (Train, Validation, and Test) for a Neural Network model. The Train dataset shows the highest F1-Score at 0.96, while the Validation and Test datasets have lower scores of 0.77 and 0.74, respectively, indicating potential overfitting to the training data.

Results



*The bar chart compares the **Final F1-Score** for a Neural Network across three datasets: Train (0.96), Validation (0.77), and Test (0.74), indicating potential overfitting as the performance drops from training to validation and test sets.*



*The bar chart compares the **Validation Accuracy** and **Test Accuracy** of six classifiers (Logistic Regression, Random Forest, XGBoost, LightGBM, CatBoost, and MLP), showing that LightGBM achieves the highest performance with a Validation Accuracy of 71.92% and Test Accuracy of 76.96%, while Logistic Regression has the lowest performance.*

Model	F1-score (Class 0)	F1-score (Class 1)	F1-score (Class 2)	F1-score (Class 3)	Macro Avg F1	Test Accuracy
Logistic Regression	0.83	0.53	0.38	0.00	0.44	71.00%
Random Forest	0.85	0.59	0.38	0.00	0.45	74.00%
XGBoost	0.83	0.61	0.42	0.00	0.47	75.00%
LightGBM	**0.85**	**0.63**	**0.48**	**0.00**	**0.49**	**76.96%**
CatBoost	0.83	0.57	0.48	0.00	0.47	73.04%
MLP	0.81	0.52	0.55	0.00	0.47	71.08%

The table compares the performance of six models (Logistic Regression, Random Forest, XGBoost, LightGBM, CatBoost, and MLP) across different metrics: F1-scores for each class (Class 0, Class 1, Class 2, Class 3), Macro Average F1-score, and Test Accuracy, with LightGBM achieving the highest overall performance.

Conclusion

The project successfully developed a robust machine learning model using the NACC-UDS dataset, achieving promising F1-scores for predicting Alzheimer's Disease progression stages, with neural networks and gradient boosting models outperforming baseline classifiers.

The data supports the hypothesis, showing improved model performance with advanced techniques like SMOTE and hyperparameter tuning.

Explore larger and more diverse datasets, including genetic and imaging data, to enhance model robustness and generalizability. Develop real-time clinical tools and applications for Alzheimer's prediction and integrate advanced techniques like model ensembling and cross-validation for improved accuracy.

References

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