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A Multimodal Deep Neural Network for Early Prediction and Detection of Alzheimer's Disease Based on MRI Images and Clinical Information

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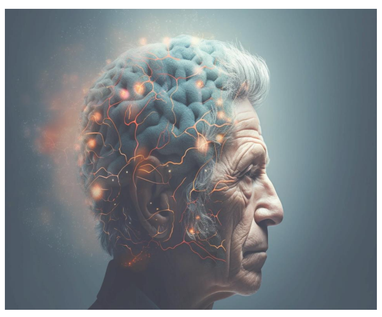
INTRODUCTION



- Alzheimer's disease is a serious neurodegenerative disorder that is prevalent among the elderly.
- **Progressive** mild cognitive impairment (pMCI) has the potential to progress into Alzheimer's disease.
- In contrast, **stable** mild cognitive impairment (sMCI) refers to a milder form of cognitive decline that does not further deteriorate over time.

OBJECTIVE

This research aims to develop a multimodal deep neural network that integrates MRI images and clinical information for early and accurate prediction and detection of Alzheimer's disease, thereby promoting personalized medical strategies.

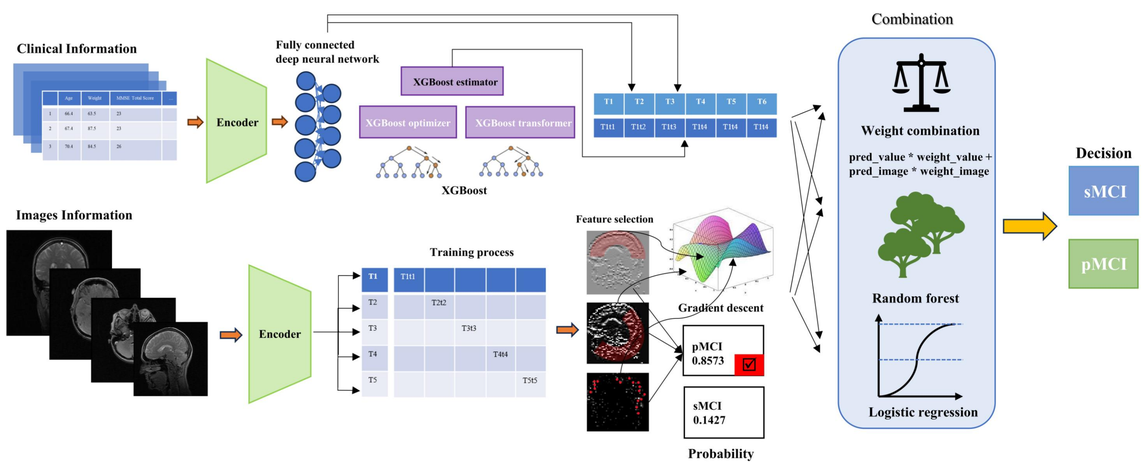
DATA SOURCE

ADNI
ALZHEIMER'S DISEASE NEUROIMAGING INITIATIVE

Current PPSB Partners for ADNI3

- Based on the diagnostic summary, we identified patients who had experienced MCI and monitored their complete **visiting history** to determine if they progressed to Alzheimer's disease within two years.
- Then we defined them with pMCI and sMCI. We extracted the MRI images and clinical information from these patients while removed unclear images and performed **augmentation** in order to generalize them and keep the balance of these groups.

METHODS



We decided to combine the MRI images and clinical data to a multimodal deep neural network. For the combination methods, We utilized weight combination, random forest and logistic regression to get the final result.

RESULTS

Table 1 Performance on MRI images

Neural Network	Accuracy	Precision	Sensitivity	F1 score
MobileNet	0.9233	0.9080	0.8449	0.8753
ResNet18	0.9097	0.8641	0.8503	0.8571
VGG19	0.3186	0.3186	1.0000	0.4832
Xception	0.5690	0.4057	0.7594	0.5289

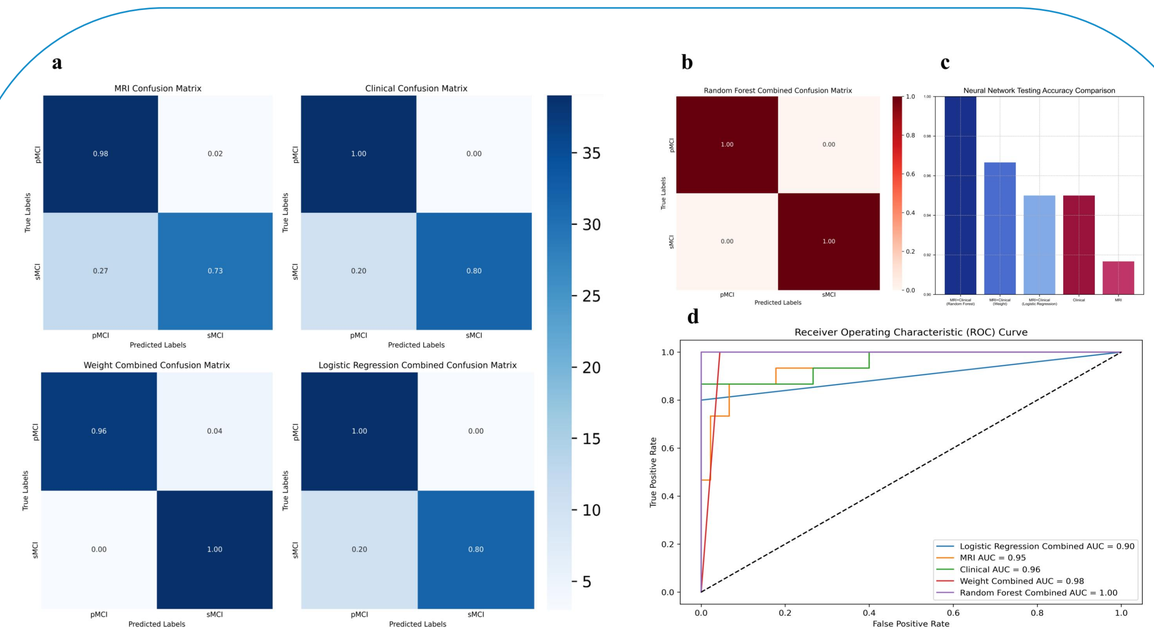
Table 2 Performance on clinical information

Neural Network	Accuracy	Precision	Sensitivity	F1 score
XGBoost	0.8500	0.6667	0.8000	0.7273
Optimized Fully connected Neural Network	0.9500	0.8000	1.0000	0.8889

Table 3 Performance on multimodal deep neural network

Neural Network	Accuracy	Precision	Recall	F1 score
MRI	0.9167	0.9167	0.7333	0.8148
Clinical	0.9500	0.8000	1.0000	0.8889
MRI+Clinical （Weight）	0.9667	0.8824	1.0000	0.9375
MRI+Clinical （Logistic Regression）	0.9500	1.0000	0.8000	0.8889
MRI+Clinical （Random Forest）	1.0000	1.0000	1.0000	1.0000

- **Table 1** shows the unimodal training results that demonstrated the modified MobileNet architecture, which yielded the best classification performance of MRI images.
- For the clinical information, we achieved best performance trained by the fully connected deep neural network shown as **Table 2**.
- **Random forest** method achieved the best performance with all testing set were predicted right to their true labels shown as **Table 3**.



Performances on unimodal deep neural networks and multimodal neural networks based on different combination methods.

- **Figure a**, confusion matrixes of adjusted unimodal neural networks on the testing set of MRI images and clinical information, and multimodal neural networks based on logistic regression combined algorithm and weight-based combined algorithm.
- **Figure b**, confusion matrix of multimodal neural network based on random forest combined algorithm.
- **Figure c**, bar chart shows the comparison of accuracy among different neural networks.
- **Figure d**, AUC curve for comparison among different neural networks.

CONCLUSIONS

This multimodal deep neural network provides early diagnosis and accurate risk prediction of Alzheimer's disease. This model can enable healthcare professionals to personalize patient management, intervene promptly, and develop tailored treatment plans. Leveraging this integrated approach has the potential to effectively slow down disease progression, improve clinical outcomes and enhance the quality of life for patients.

REFERENCES

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