Predicting Alzheimer's Disease with Deep Learning

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Problem Statement

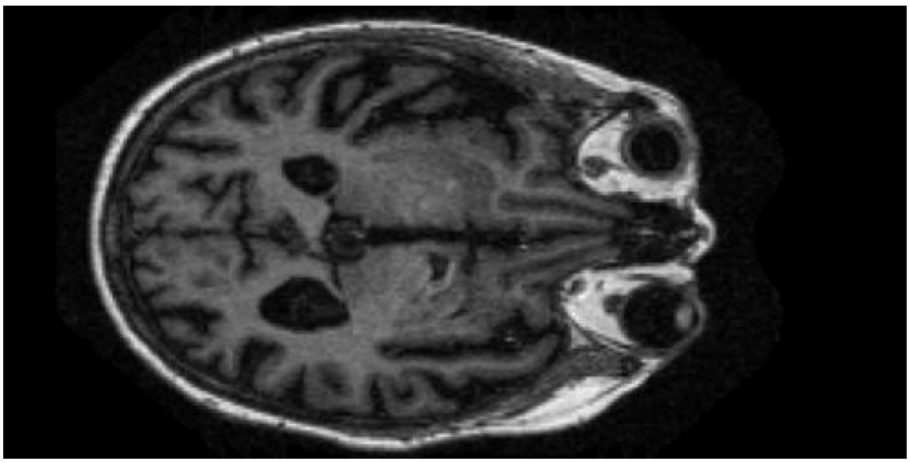
We aim to leverage the OSAIS MRI dataset to develop a machine learning model capable

Exploratory Data Analysis

View Images

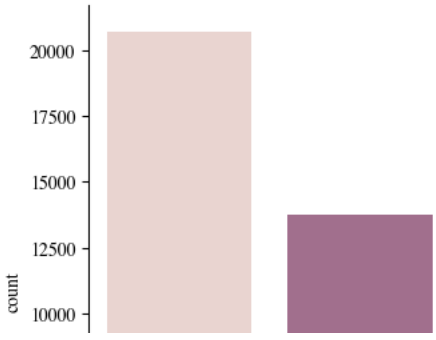
View Image from No Dementia | View Image from Very Mild Dementia | View Image from Mild Dementia

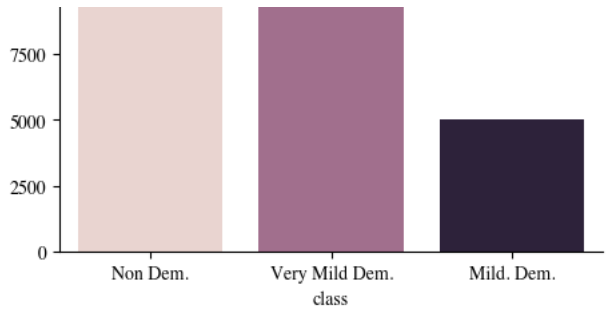
Mild Dementia



Data Distribution

Show Class Distribution | Show distribution by gender | Show distribution by age | Show distribution by education | Show distribution by socio-economic





Number of patients for each class

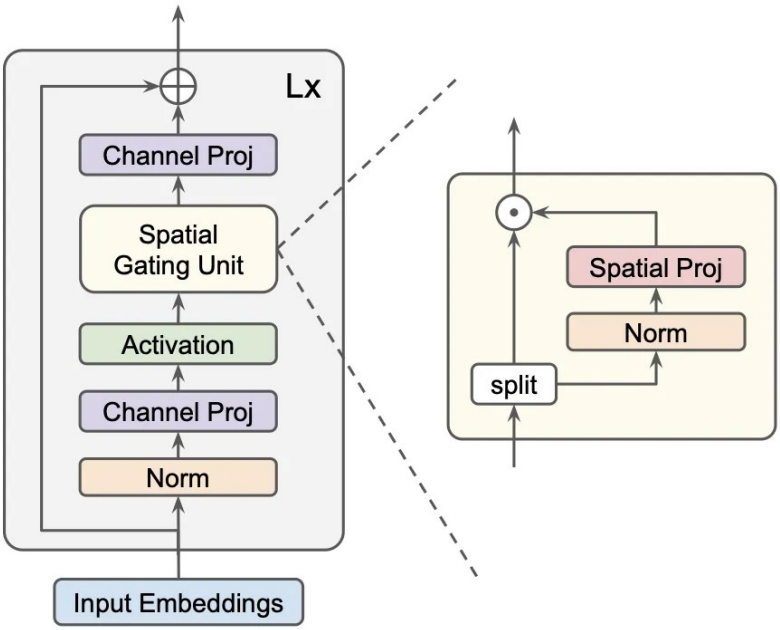
Show distribution by MMSE | Show distribution by eTIV | Show distribution by NWBV | Show distribution by ASF

Modeling

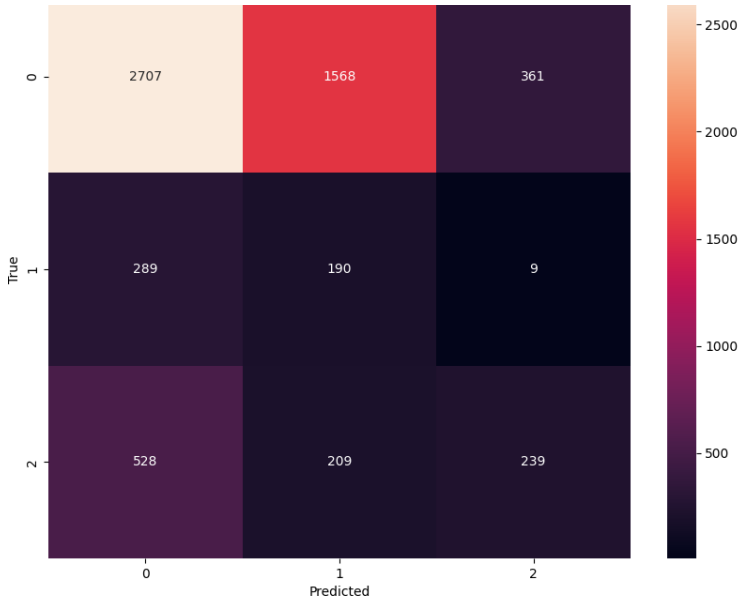
Gating Multilayer Perceptron (gMLP)

GMLP

- GMLP is a variant of multilayer perceptrons introduced in the paper linked above.
- It is an MLP with special layers called gating layers.
- Convilutional neural networks perform well but have many parameters
- GMLP achieves similar performance but with modest number of parameters.



GMLP architecture from arXiv:2105.08050



GMLP confusion matrix

Accuracy = 0.51

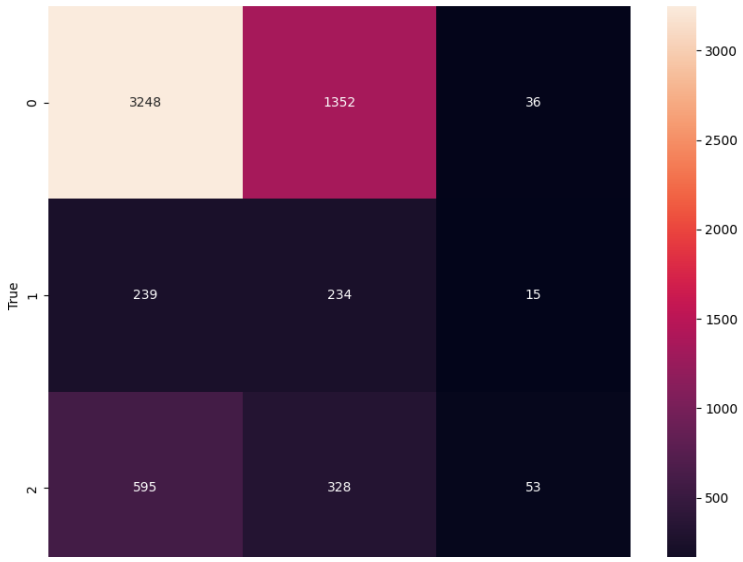
F1 = 0.37

COH = 0.06

Run Demo Correct Label Model Label

RESNET 50 with Metadata

- Images were trained on the ResNet50 architecture
- Output of convolution blocks concatenated with tabular metadata
- Combined features trained with MLP to generated classification output



Confusion matrix for ResNet 50 with metadata

Accuracy = 0.58

F1 = 0.35

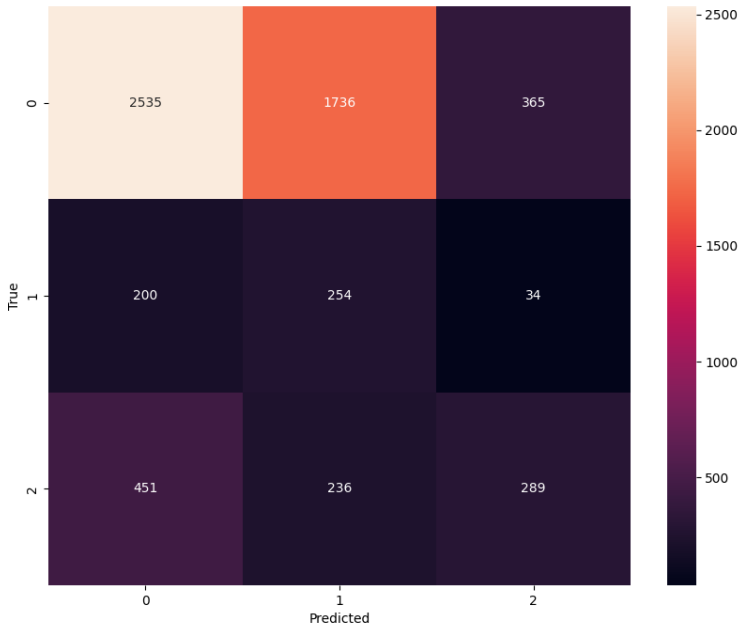
COH = 0.09

Run Demo 2 Correct Label 2 Model Label 2

CNN with Attention:

CNN with CBAM Overview

- Enhances feature focus and model interpretability in image analysis tasks. CBAM's Role in CNNs
- Channel Attention: Prioritizes 'what' features to focus on by weighting channels.
- Spatial Attention: Identifies 'where' to focus, emphasizing critical regions.



Confusion matrix for CNN with Attention

Run Demo 3 Correct Label 3 Model Label 3

Accuracy = 0.50

F1 = 0.39

COH = 0.11

Grad-CAM for Visualization

- Produces heatmaps that highlight influential areas affecting the model's decisions. Facilitates understanding of the model's internal reasoning process. Importance for Explainable AI (XAI)
- Offers transparency in model predictions, crucial for trust in sensitive applications like healthcare.
- Assists in model validation and iterative refinement by aligning predictions with domain expertise.

Show XAI

Future Work and Conclusion

Generate more images of the very mild dementia and mild dementia classes

- The dataset has more images of the no dementia class compared to the other classes
- This in-balance skews the model towards predicting often that there is no dementia
- The model learns the features associated with no dementia but not how to distinguish between no dementia and other classes.
- For example, the confusion matrices show that the model does not distinguish well between no dementia and very mild dementia, making early diagnosis challeging

Implement 3D models

- The brain images are 3-Dimensional
- We have used each slice of the brain as an individual image, ignoring 3D spatial informations.
- The spatial relations between different pixels may be necessary in predicting AD.
- We may consider models such as:

1. 3D Convolutional Neural Networks
2. 3D Reccurent Visual Attention Networks (RVN)

- The state of the art is ~90% achieved by an RVN and a Transformer model in arXiv:2011.14139

In conclusion

We have used GMLP, ResNet Model with metadata and CNN with Attention to predict the severity of AD

We established modest results ~0.50% accuracy but promising with some improvements.

One improvement is to generate data of under-represented classes artificially.

Another possible improvement is to use 3D models to also account for the spatial propoerties of the brain more accurately.

Thank you!