Severity Classification of Alzheimer's Disease Using MRI Images

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Introduction: Alzheimer's Disease

- Form of dementia
- A leading cause of death in adults 65+ [1]
- No cure, treatments can slow progression [2]
  - Early detection is crucial [3]
- MRIs can be used to see brain degeneration
- Classification models are currently being explored in order to help interpret images

Problem Statement

- Can we create a tool that can correctly classify Alzheimer's severity in MRI images?

- Is it better to train the tool on all levels of severity or just cases of very mild dementia and no dementia?

- Using the data, we will build a multiclass image classification model employing Convolutional Neural Networks (CNNs).

- Build a binary model that can more accurately detect very mild dementia by training a CNN exclusively on brain images with no signs of dementia and images with very mild dementia.
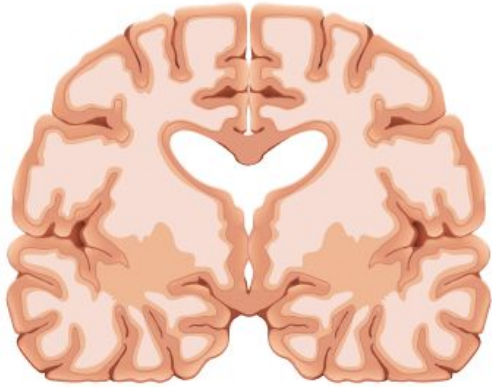
Data Source

- Publicly available brain MRI images from a Kaggle dataset
- Selected because our model is proof-of-concept
  - For demonstration purposes only
- Origin of data is unknown, no patient info included
- No data dictionary included
- Diagnosis of each image produced from folders
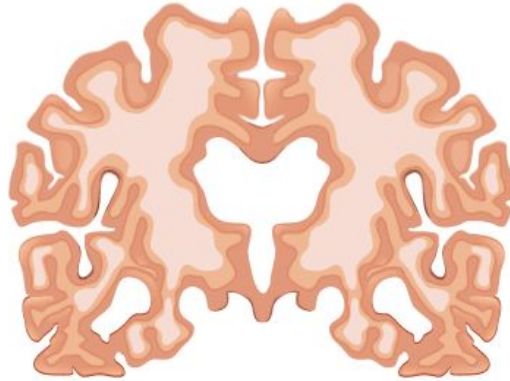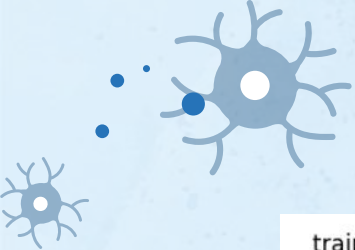 - (data was pre-sorted)
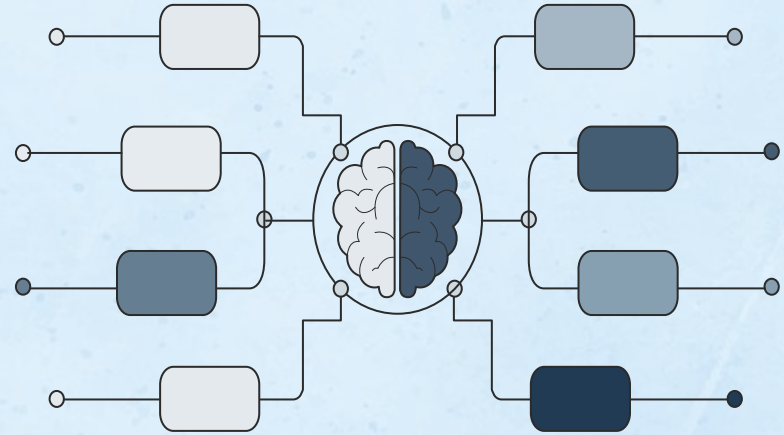
Progression of Alzheimer's Disease
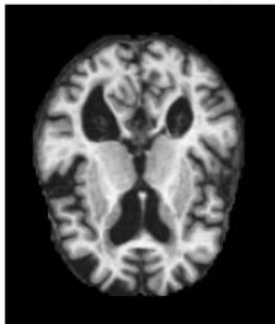

Healthy Brain   Mild Alzheimer's Disease   Severe Alzheimer's Disease

Sample Brain Images
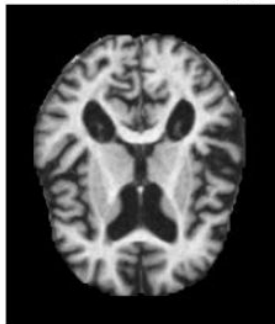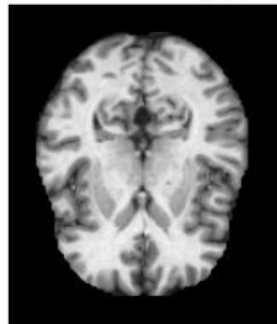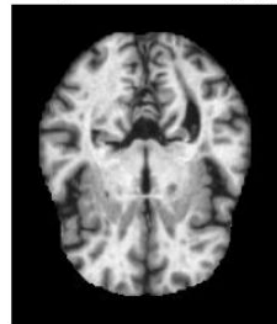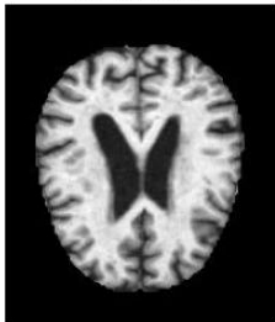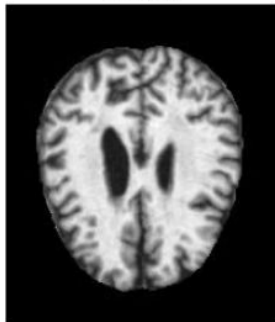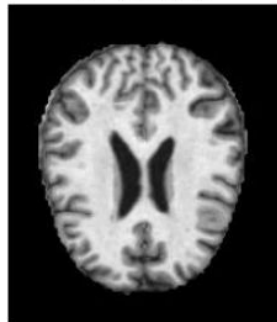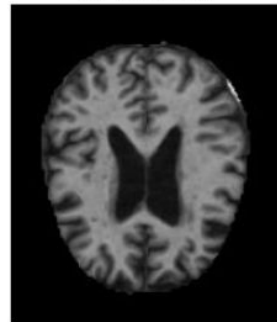
Baseline Class Summary

	Training Counts	Training Percentages	Testing Counts	Testing Percentages
No Dementia	2560	50%	640	50%
Very Mild Dementia	1792	35%	448	35%
Mild Dementia	717	14%	179	14%
Moderate Dementia	52	1%	12	1%
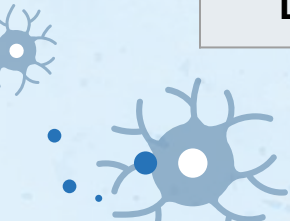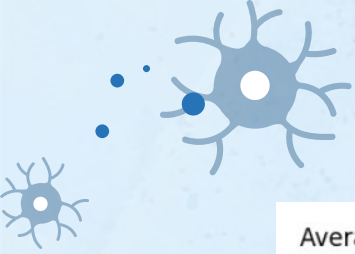
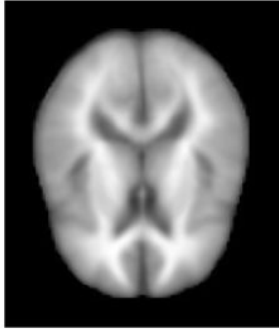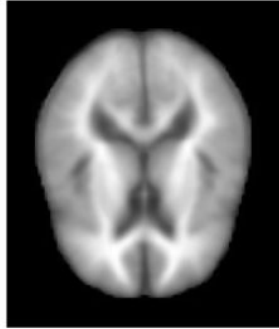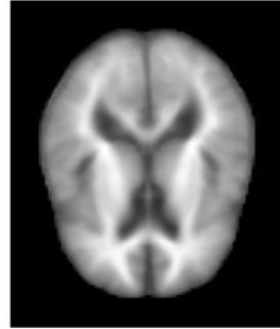# Exploratory Data Analysis
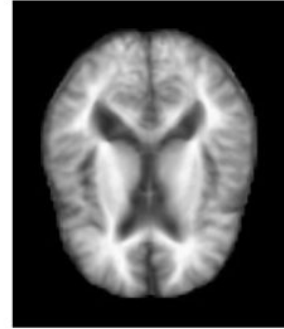

Average No Dementia | Average Very Mild Dementia | Average Mild Dementia | Average Moderate Dementia

Fourth Quartile St. Dev. No Dementia | Fourth Quartile St. Dev. Very Mild Dementia | Fourth Quartile St. Dev. Mild Dementia | Fourth Quartile St. Dev. Moderate Dementia
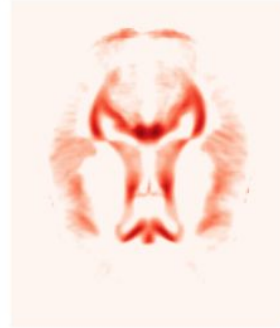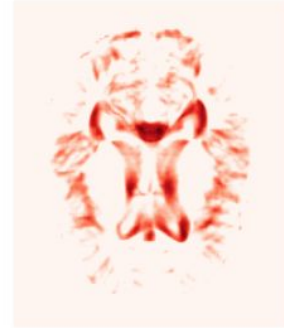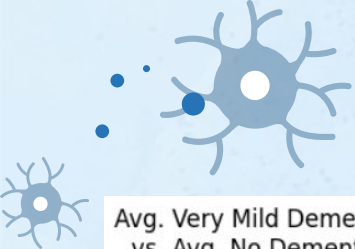
Exploratory Data Analysis

Avg. Very Mild Dementia vs. Avg. No Dementia
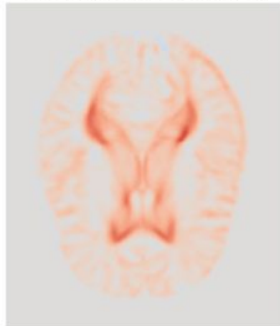
Avg. Mild Dementia vs. Avg. No Dementia
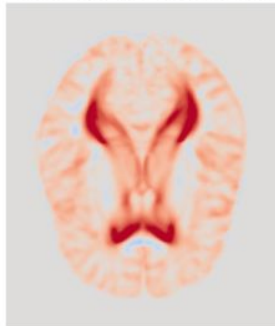
Avg. Moderate Dementia vs. Avg. No Dementia
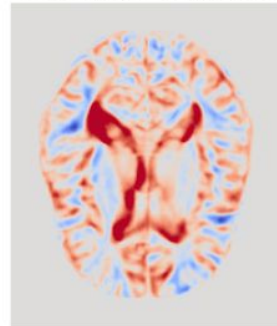
Avg. No Dementia vs. Avg. Very Mild Dementia
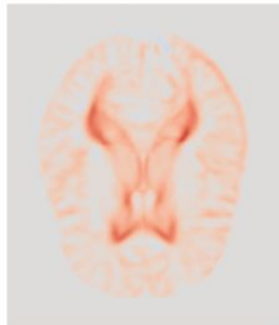
Avg. Very Mild Dementia vs. Avg. Mild Dementia
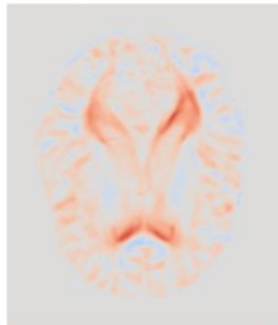
Avg. Mild Dementia vs. Avg. Moderate Dementia
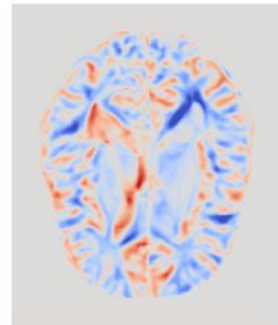
Qualitative Color Legend

More Brain Degeneration

Less* Brain Degeneration

* Not supposed to happen. Likely an artifact of imaging or due to small sample sizes for more severe dementia classes.

Modeling Process

Multi-Class Models

| No Dem. | V.M. Dem | Mild Dem | Mod Dem |

Manually-Built Models:
CNNs, various image processing and modeling techniques

Pre-Trained Models:
Openly available pre-optimized models including
- VGG16
- VGG19
- EfficientNetB0
- InceptionV3

Binary Models

| No Dem. | VM Dem |

Manually-Built Models:
- Two models from multiclass

Pre-Trained Models:
- InceptionV3
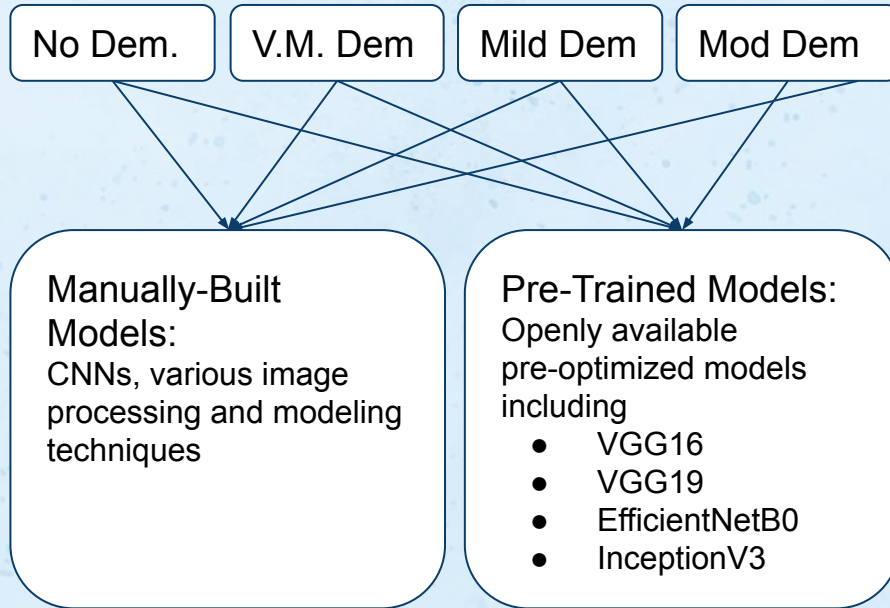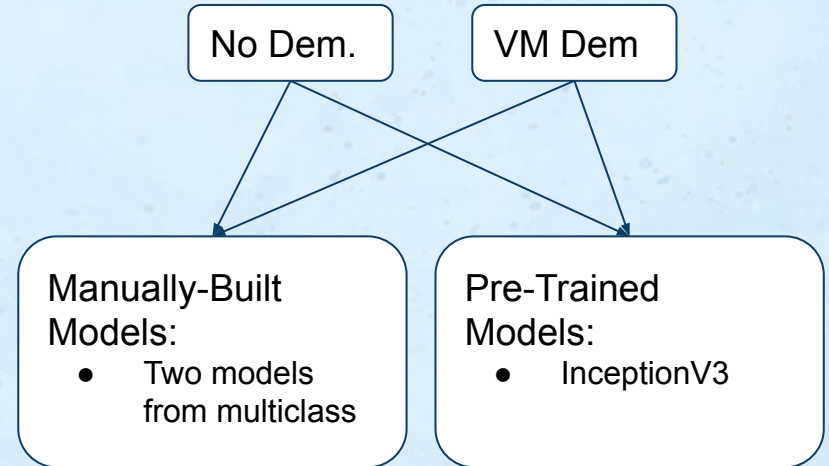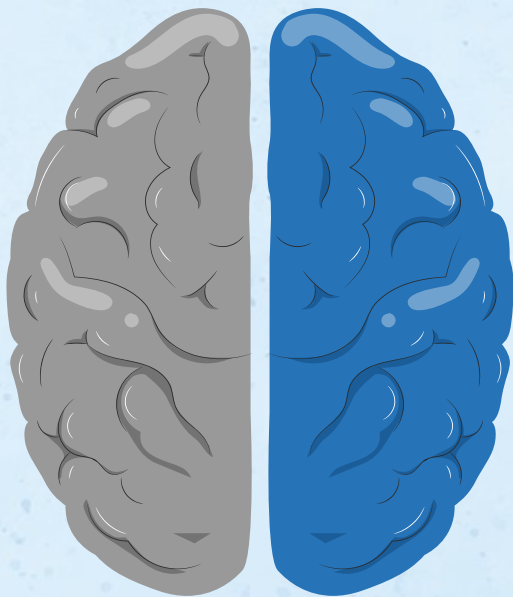
01

Multi-Class Modeling

Manually-Built Models

CLASS	Initial	Optimized	Optimized with Class Weights	Optimized with Image Aug.	Optimized With Regularization
Model Accuracy	0.573	0.527	0.672	0.522	0.522
Recall No Dementia	0.47	0.65	0.82	0.92	0.92
Recall Very Mild	0.83	0.29	0.58	0.17	0.17
Recall Mild	0.34	0.64	0.41	0.03	0.03
Recall Moderate	0.17	0.83	0.33	0.00	0.00
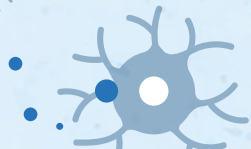
Pre-Trained Models

01 **EfficientNetBØ**

Quick and efficient, smart learning to self-adjust certain modeling features to get the best results

02 **VGG19**

Consists of 19 layers, can capture intricate details in a simple but effective manner

03 **VGG16**

Another variant of VGG architecture, 16 layers, less does not necessarily mean worse

04 **InceptionV3**

Uses a combination of different filters and techniques, captures both fine and broad details
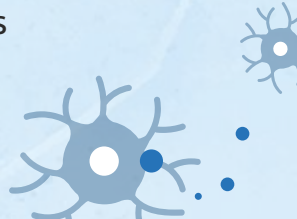
Pre-Trained Models

CLASS	ENetB0	VGG19	VGG16	IncepV3
Model Accuracy	0.553	0.549	0.397	0.714
Recall No Dementia	0.54	0.55	0.07	0.75
Recall Very Mild	0.69	0.43	0.96	0.77
Recall Mild	0.27	0.84	0.18	0.48
Recall Moderate	0.33	0.67	0.00	0.08
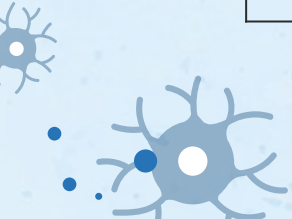
02

Binary Class Modeling
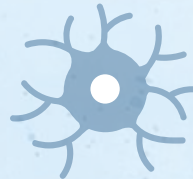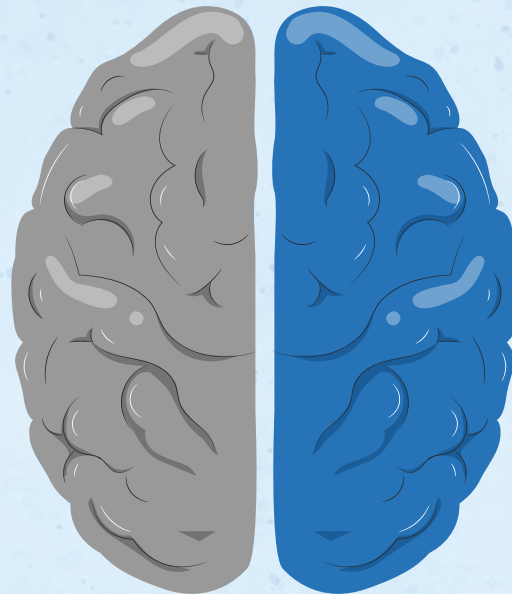
Binary Models

CLASS	Initial	Optimized	IncepV3
Model Accuracy	0.640	0.812	0.588
Recall No Dementia	0.50	0.83	1.00
Recall Very Mild	0.54	0.78	0.00
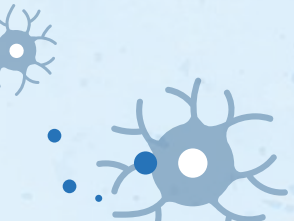
Conclusions

- Models can be built that will perform better than the null model, but are not yet to the level of accuracy or recall required for use in a diagnostic situation

- Binary classification models appear to perform better at classifying the no dementia and very mild dementia classes than the multiclass models

  - While more modeling is needed, a binary model may be preferable for early diagnostic purposes

Next Steps

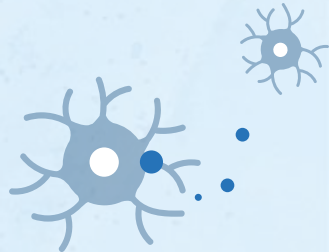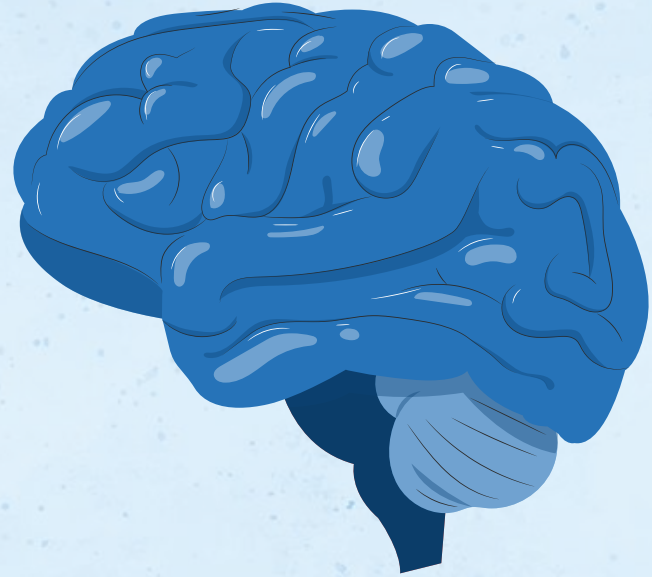- Additional modeling is required to improve model performances. The following steps should be taken in subsequent modeling stages:

- Measures should be taken to enhance model stability and the above models should then be further verified

- Pretrained models are available which are specifically geared towards medical imaging applications and should be implemented in the next stages of modeling

- Additional image augmentation techniques could be explored

- A deeper exploration of image classification techniques could be performed by referencing models which have more successfully classified these images

Sources

1. https://www.cdc.gov/aging/aginginfo/alzheimers.htm#:~:text=Alzheimer%27s%20disease%20is%20the%20most,thought%2C%20memory%2C%20and%20language.

2. https://www.nia.nih.gov/health/how-alzheimers-disease-treated#:~:text=Treatment%20for%20mild%20to%20moderate%20Alzheimer's%20disease,-Treating%20the%20symptoms&text=Galantamine%2C%20rivastigmine%2C%20and%20donepezil%20are,some%20cognitive%20and%20behavioral%20symptoms.

3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7050025/

4. https://www.kaggle.com/datasets/tourist55/alzheimers-dataset-4-class-of-images

5. Slidesgo - https://slidesgo.com/theme/learn-more-about-the-nervous-system
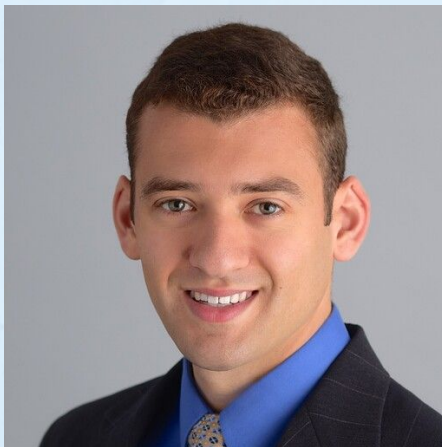
Thanks for Listening!

Any Questions?

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