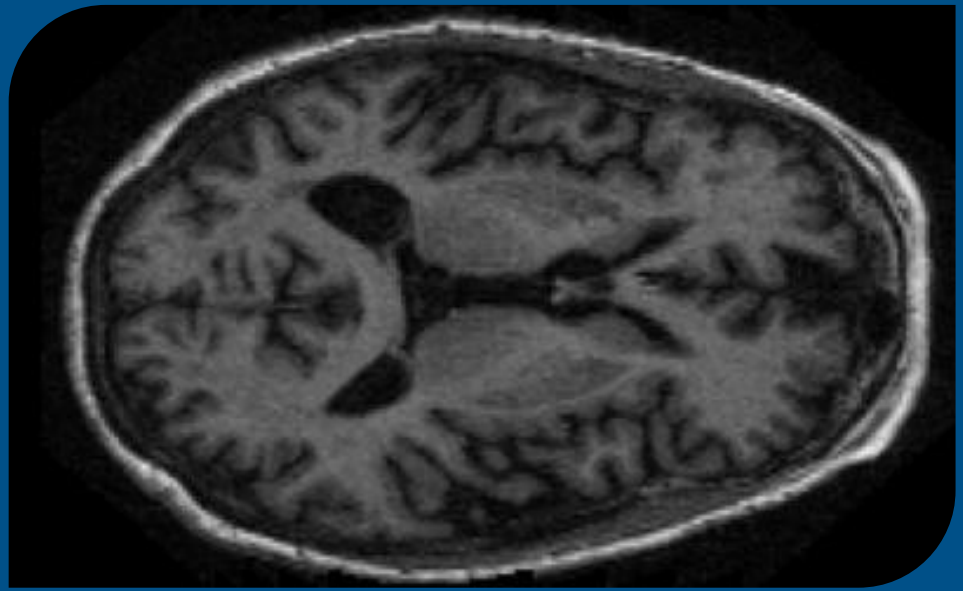
12.12.25

STAN47 – Final Project: Alzheimer's

- Predicting dementia using CNN image recognition



Markus, William and Xin

1. Introduction, Data & Research Question
2. Data Augmentation
3. Models & Theory
4. Results
5. Conclusion

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"Alzheimer's disease is the most common form of dementia, a brain disorder that slowly destroys a person's memory and thinking skills"

https://www.nia.nih.gov/health/alzheimers-and-dementia/what-alzheimers-disease

Data:
OASIS MRI dataset

- Dataset containing 80 000 MRI Brain scan images
- Divided into four categories based on Alzheimer's progression
  - No dementia
  - Very Mild dementia
  - Mild dementia
  - Moderate dementia

“Can we construct a CNN architecture which can learn to find dementia based on brain-scan images?”

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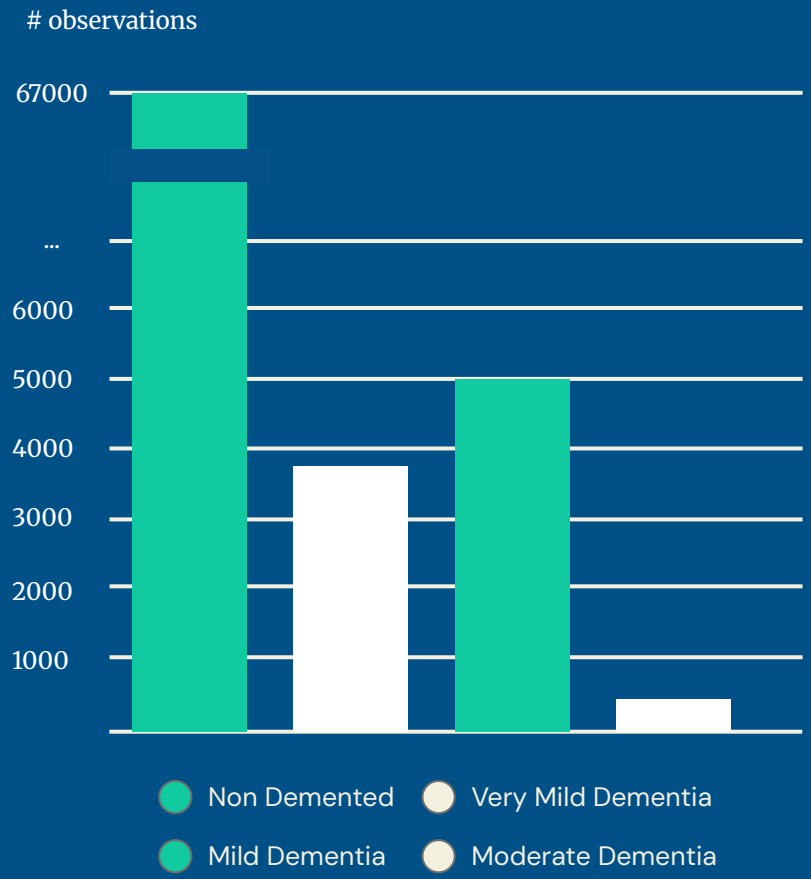
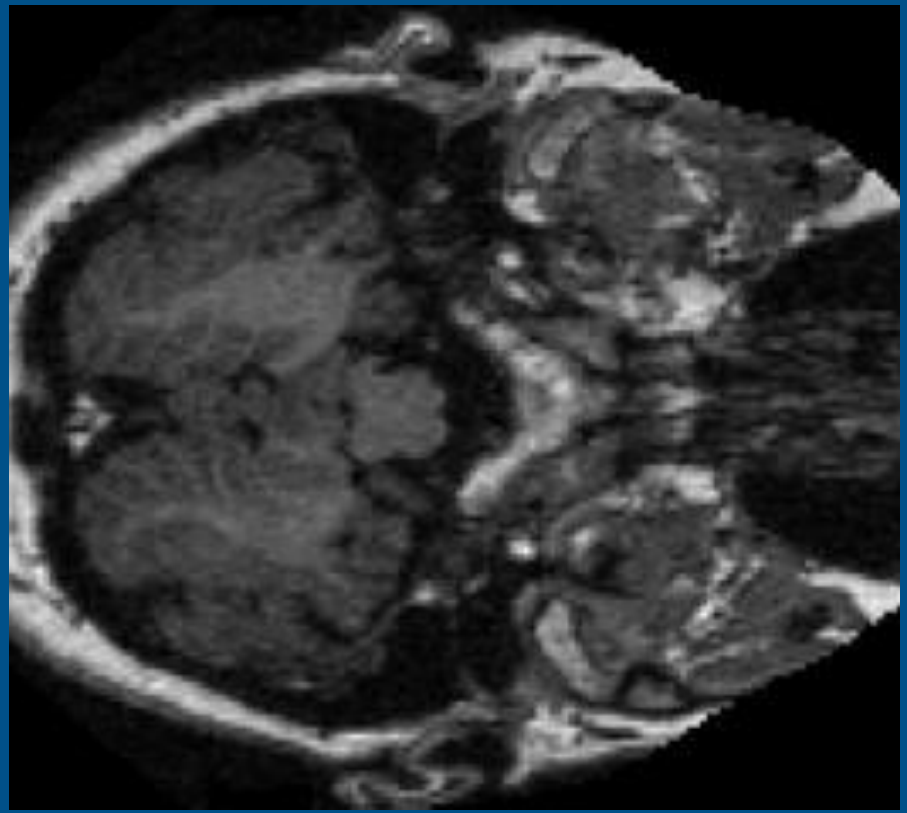
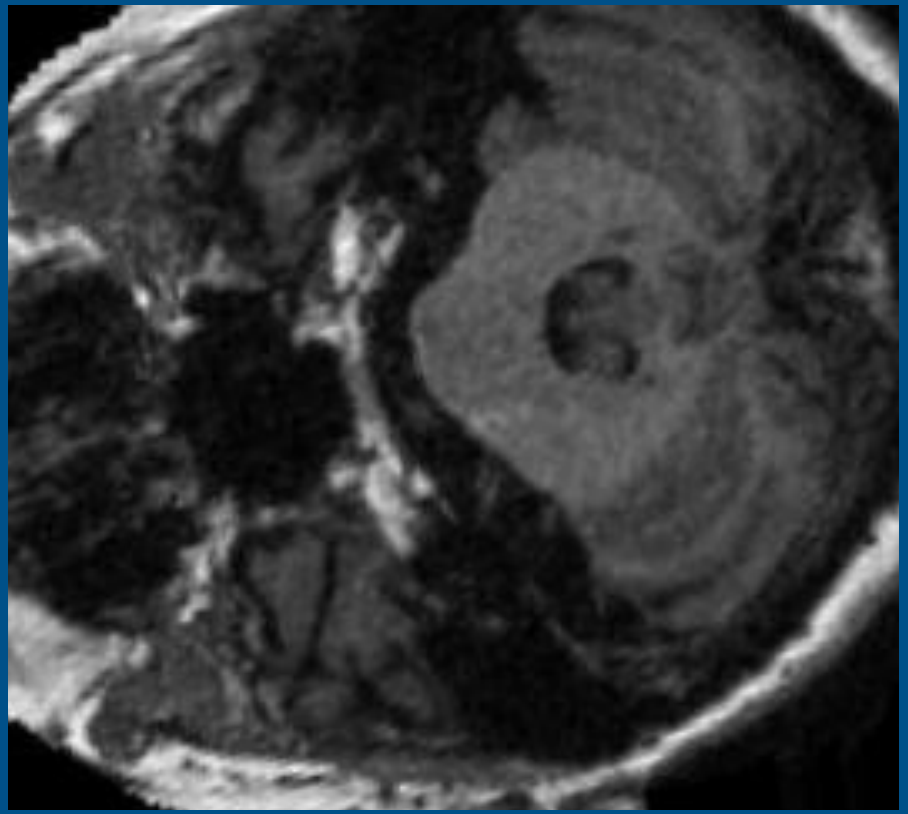
Imbalanced Data

- The dataset is very imbalanced
- Distribution
  - Non Demented: 67000
  - Very Mild: 3900
  - Mild: 5000
  - Moderate: 480
- Solution: Data Augmentation:
  - Moderate dementia images are oversampled using augmentation



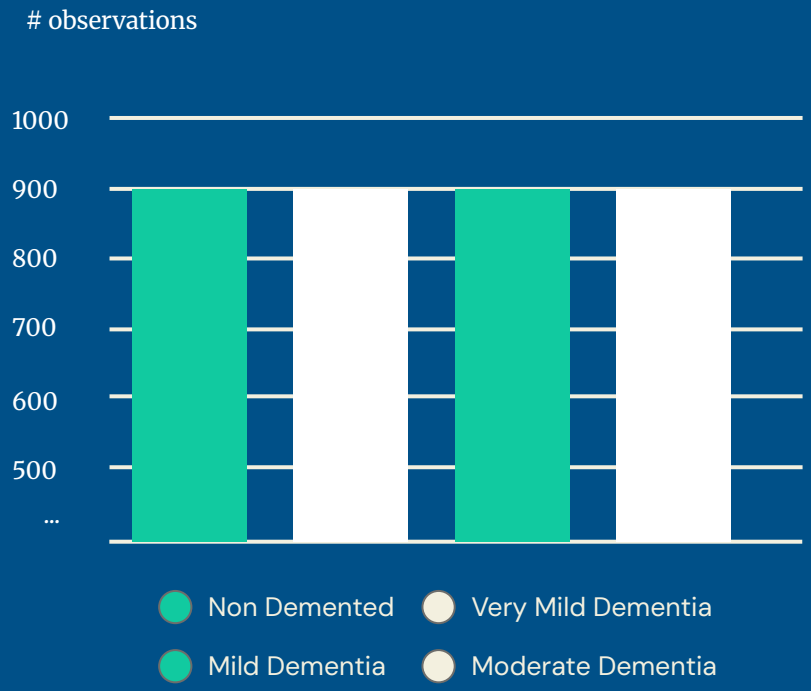




Note: Arbitrarily chosen pictures, of original to the left and an augmented image to the right

New dataset

- Oversampling of minority (using DA)
- Undersampling the rest
- Distribution
  - Non Demented: 900
  - Very Mild: 900
  - Mild: 900
  - Moderate: 900



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"Convolutional Neural Networks (CNNs) are a specialized class of neural networks designed to process grid-like data, such as images. They are particularly well-suited for image recognition and processing tasks."

https://www.geeksforgeeks.org/convolutional-neural-network-cnn-in-machine-learning/

Convolutional neural network

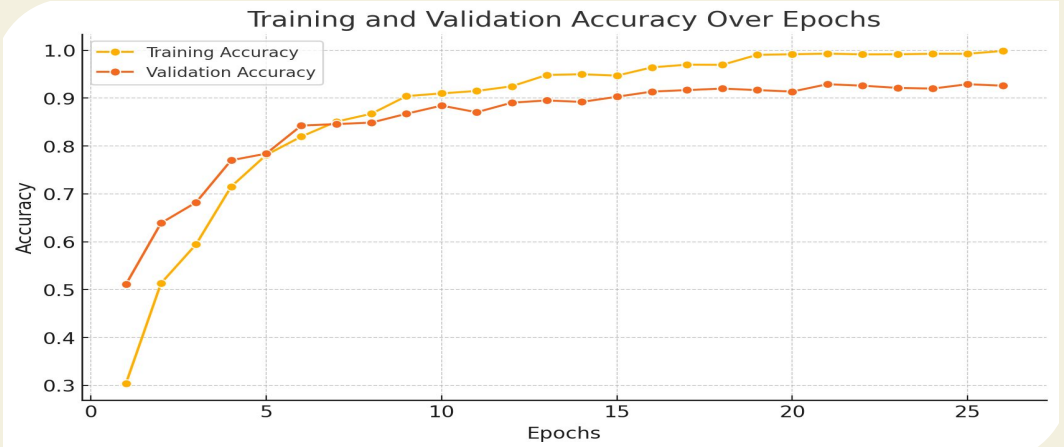
- Consists of convolutional layers that read the images
- Our architecture consists of four convolutional layers each with a max pooling and dropout (with a rate of 0.1)
- Also includes one fully connected layer with more aggressive regularisation (0.5)
- Ending with a 4-node softmax output layer

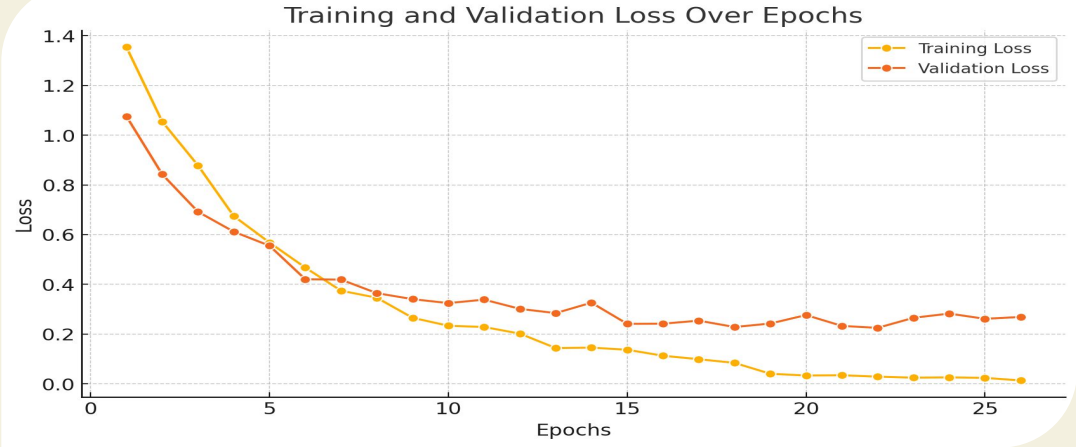
Table 1: CNN Architecture

Layer Type	Filters/Units	Kernel Size	Activation	Dropout
Input	-	(96, 96, 1)	-	-
Conv2D	32	(3,3)	ReLU	-
MaxPooling2D	-	(2,2)	-	-
Dropout	-	-	-	0.1
Conv2D	64	(3,3)	ReLU	-
MaxPooling2D	-	(2,2)	-	-
Dropout	-	-	-	0.1
Conv2D	64	(3,3)	ReLU	-
MaxPooling2D	-	(2,2)	-	-
Dropout	-	-	-	0.1
Conv2D	64	(3,3)	ReLU	-
MaxPooling2D	-	(2,2)	-	-
Dropout	-	-	-	0.1
Flatten	-	-	-	-

Training and optimisation process

- Model was compiled using the Adam optimizer (learning rate of 0.001). Loss function was categorical cross-entropy
- Early stopping and learning rate adjustment was introduced
- Validated during training on 20% of the data





Training and optimisation process

-Baseline CNN train Accuracy: 90.28%

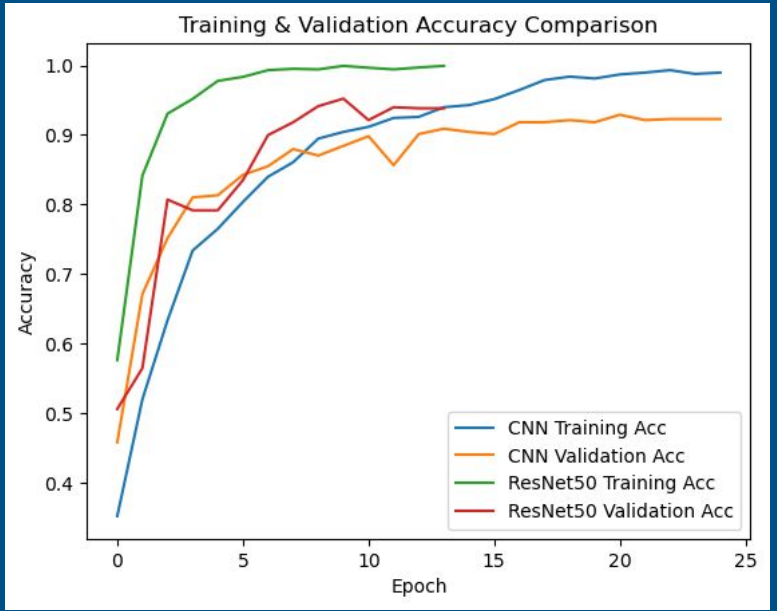
-ResNet50 Test Accuracy: 92.50%

-ResNet50 is overfitting.

Discussion:

-Does full fine-tuning ResNet50 resulted in a better-performing model?

-ResNet50 is overfitting. Why?



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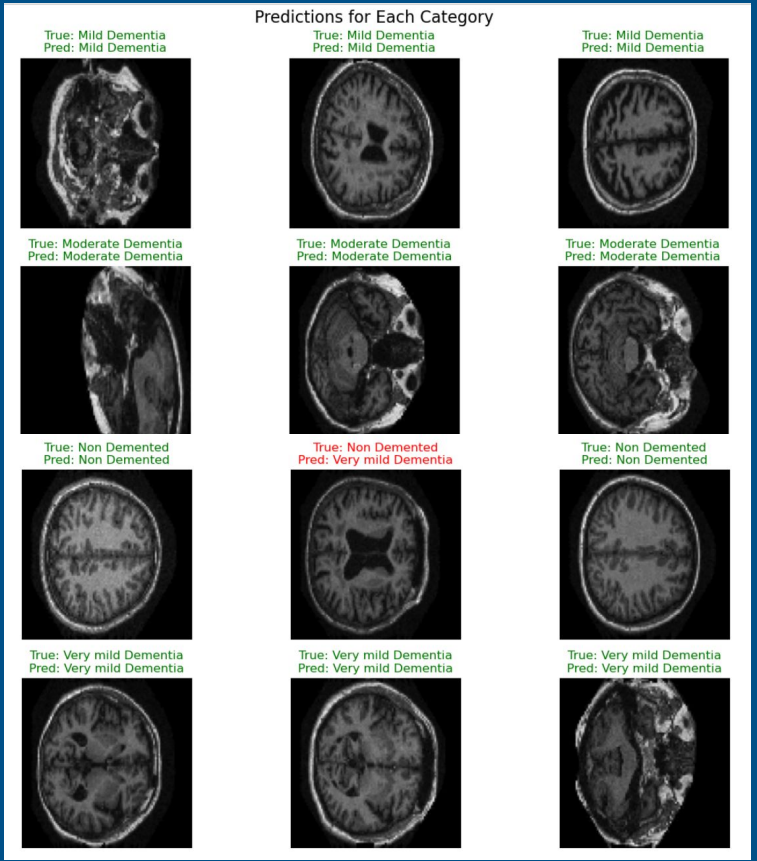
Predictions

Highlights:

- One image classified wrongly (of the sample)
- Are some categories harder to predict than others?
- Are some categories more or less important?



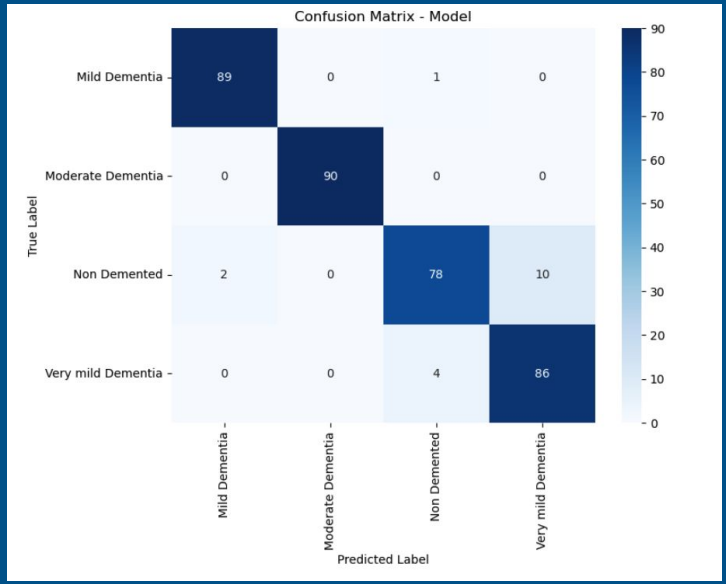
Confusion Matrix (Our model)

Highlights:

- Overall excellent metrics
- Best in classifying the Moderate class
- Worst in differentiating between Non and Very mild classes

Discussion:

- Hard to separate between very mild and no dementia, problematic if trying to catch early-stage Alzheimer's
- Better at catching the more developed and more dangerous dementia



	precision	recall	f1-score	support
Mild Dementia	0.98	0.99	0.98	90
Moderate Dementia	1.00	1.00	1.00	90
Non Demented	0.94	0.87	0.90	90
Very mild Dementia	0.90	0.96	0.92	90
accuracy			0.95	360
macro avg	0.95	0.95	0.95	360
weighted avg	0.95	0.95	0.95	360

Confusion Matrix (ResNet50)

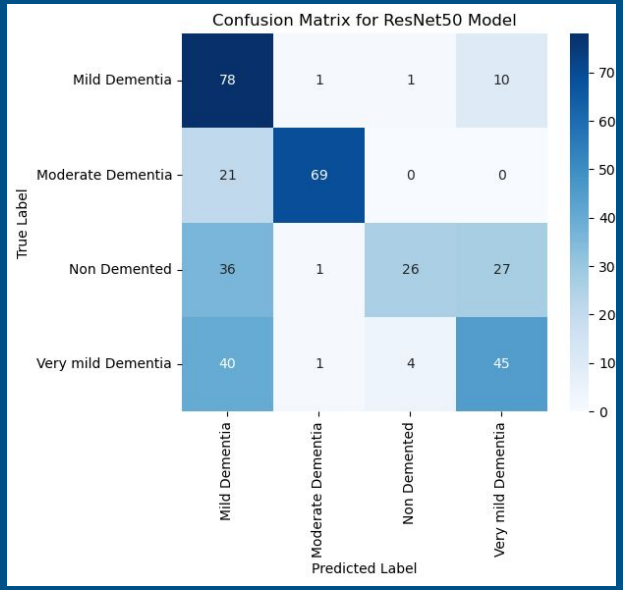
Highlights: Test accuracy was 60%

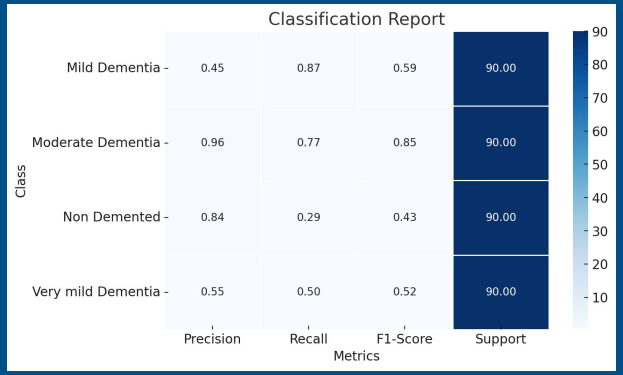
- Metrics vary over classes
- Only on the moderate class does the model perform well
- The model is not learning meaningful features.

Discussion:

:

- ResNet50 trained on natural images might not be Suitable for Medical Images.
- EfficientNet or DenseNet is better for medical images.
- Use Feature Extraction instead of Full fine-tuning.





Conclusion

High accuracy

- Model was successfully trained
- Data augmentation was utilised effectively
- Hard to discern between very mild dementia and non-dementia
- Moderate dementia was easiest to find and classify
- Transfer Learning is not a "one-size-fits-all" solution.

Author Contributions

- Markus Gerholm: Modeling and coding of CNN model
- William Nordansjö: Presentation, coordination and coding support
- Xin Wang: Modeling and coding of ResNet50 model as well as comparisons between both models