Alzheimer's Disease Prediction Presentation
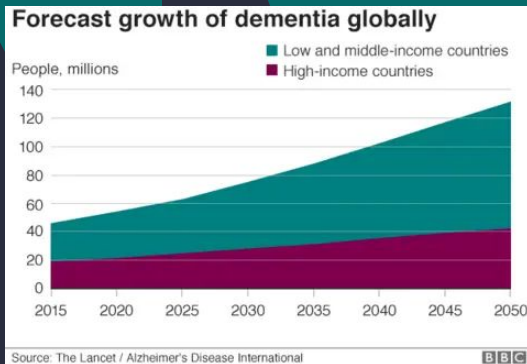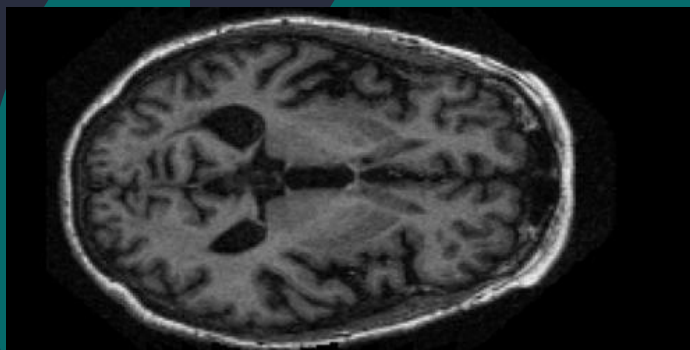
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Problem Overview & Goals

Problem:
- **Growing concerns for Dementia**

Goals:
- **Create a multiclass image classifier that can identify various stages of Dementia.**

MRI ID	The unique number of tests (354 in total).
Subject ID	The number of unique patients (142 in total). One patient may be visiting multiple times for MRI tests, so the number of MRI tests (354) is larger than the number of subjects.
Visit	Chronological visit number of a patient.
MR Delay	The delay since the last visit.
Gender	Male (M) or Female (F).
Hand	Right (R) or Left (L).
Age	Ages of the patients vary between 60 to 98.
EDUC	EDUCation level of the patients vary between 6 to 23 representing years of education.
SES	Socio-Economic Status of the patients assigned through the Hollingshead Index of Social Position. 1 representing the highest status to 5 representing the lowest status (Hollingshead 1975).
MMSE	Mini-Mental State Examination value ranges between 0 to 30. In MMSE, a health professional asks a patient a series of questions designed to test a range of everyday mental skills. The questions mainly cover preliminary arithmetic problems, simple memory tests, and recognition of different orientations of objects. A score of 20 to 24 suggests mild dementia, 13 to 20 suggests moderate dementia, and less than 12 indicates severe dementia (*What is Dementia?* n.d.), (Folstein et al. 1975).
CDR	Clinical Dementia Rating. 0 indicates No dementia, 0.5 indicates very mild dementia, 1 indicates mild dementia and 2 indicates moderate dementia (Morris 1994).
eTIV	estimated Total Intra-cranial Volume (in cm^3) of the brain (proportional to the size of the skull, can be obtained from MRI image) (Buckner et al. 2004).
nWBV	normalized Whole-Brain Volume, expressed as a percent of all voxels (can be obtained from MRI image) (Buckner et al. 2005).
ASF	Atlas Scale Factor is the volume scaling factor for brain size (proportional to nWBS and eTIV (Buckner et al. 2004)).
Class values	Three class values. Nondemented, Converted and Demented.

Forecast growth of dementia globally

People, millions
- Low and middle-income countries
- High-income countries

Source: The Lancet / Alzheimer's Disease International — BBC

Age Group	N	Non-Demented				Demented				CDR 0.5/1/2
		n	mean	male	female	n	mean	male	female	
<20	19	19	18.53	10	9	0		0	0	0/0/0
20s	119	119	22.82	51	68	0		0	0	0/0/0
30s	16	16	33.38	11	5	0		0	0	0/0/0
40s	31	31	45.58	10	21	0		0	0	0/0/0
50s	33	33	54.36	11	22	0		0	0	0/0/0
60s	40	25	64.88	7	18	15	66.13	6	9	12/3/0
70	83	35	73.37	10	25	48	74.42	20	28	32/15/1
80s	62	30	84.07	8	22	32	82.88	13	19	22/9/1
≥90	13	8	91.00	1	7	5	92.00	2	3	4/1/0
Total	416	316		119	197	100		41	59	70/28/2

Table 2. Summary of subject demographics and dementia status.
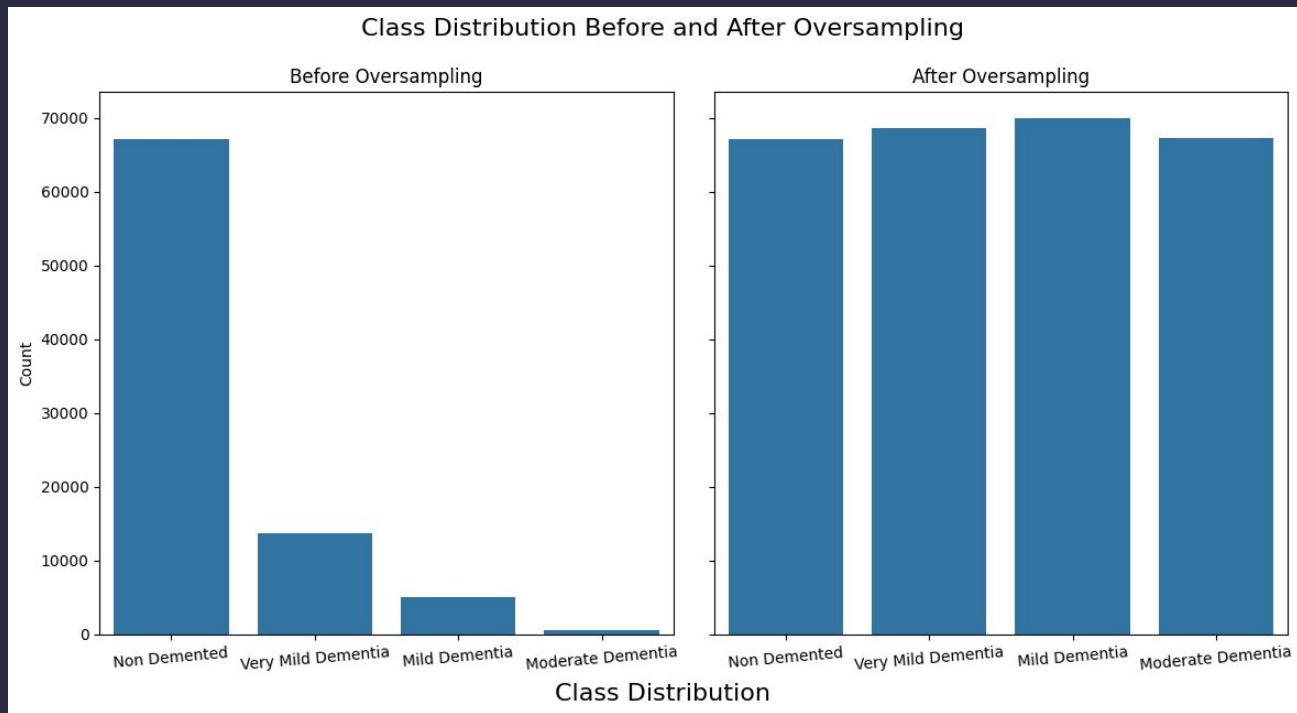
Dataset Summary

<u>Oasis-1</u>

- **Public dataset of MRI scans and clinical data from Washington U**

- **About half were college-aged, most of the rest were elderly with some middle-aged people**

- **Heavy class imbalance due to only a few patients having any form of dementia**

- **Limited dataset, overfitting was very common**

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Class Imbalance

Oversampling the OASIS-1 Dataset

Modeling Pipeline: Training on ResNet-18

- ResNet-18 was chosen as the final architecture for the CNN-Model (ResNet-50 was considered but was ultimately considered unnecessary)

- Training set was a combination of undersampling the Non-Dementia Class while oversampling the minority classes

- Validation set is 10% of the augmented OASIS-1 dataset

- Test set is the remaining 10% of the dataset

Training Process

```python
class ResNet18(nn.Module):
    def __init__(self, num_classes=2):
        super(ResNet18, self).__init__()
        self.resnet = models.resnet18(pretrained=True)
        self.resnet.fc = nn.Linear(self.resnet.fc.in_features, num_classes)

    def forward(self, x):
        return self.resnet(x)
```

- **The ResNet-18's final layer was modified**

- **It is linearly transformed, with the input features numbering 512 and the output features numbering 4 (default is 2)**

- **The model is then forward propagated by reapplying the ResNet-18 model**

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Early Testing Confusion Matrix
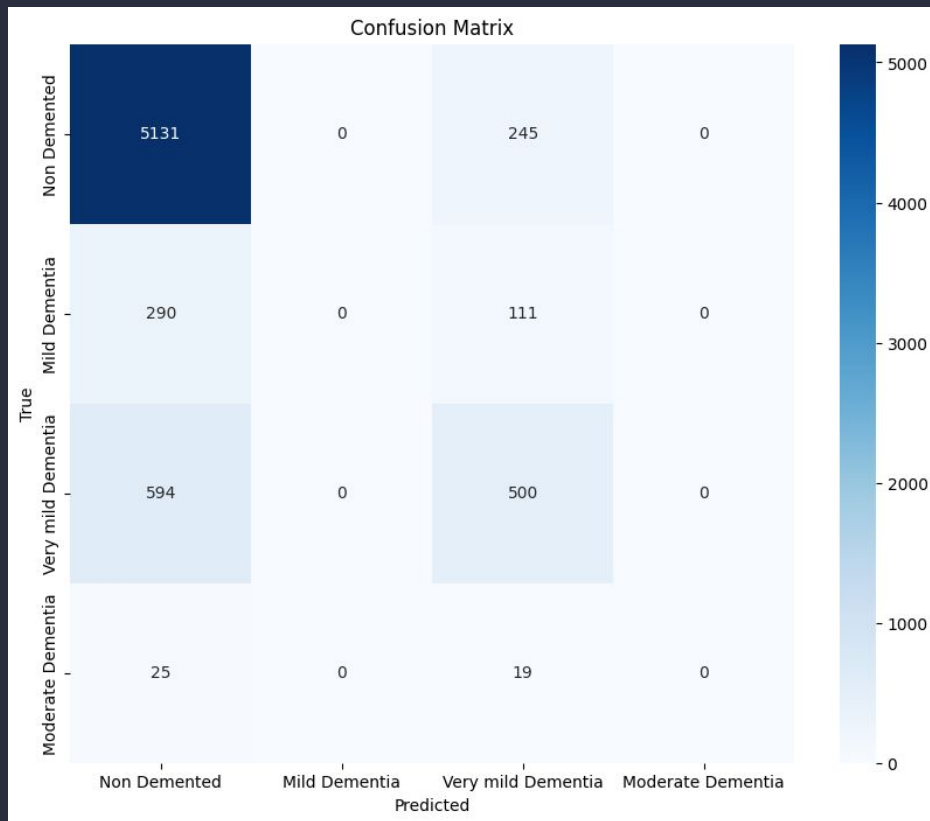
Using the Entire Oversampled Dataset
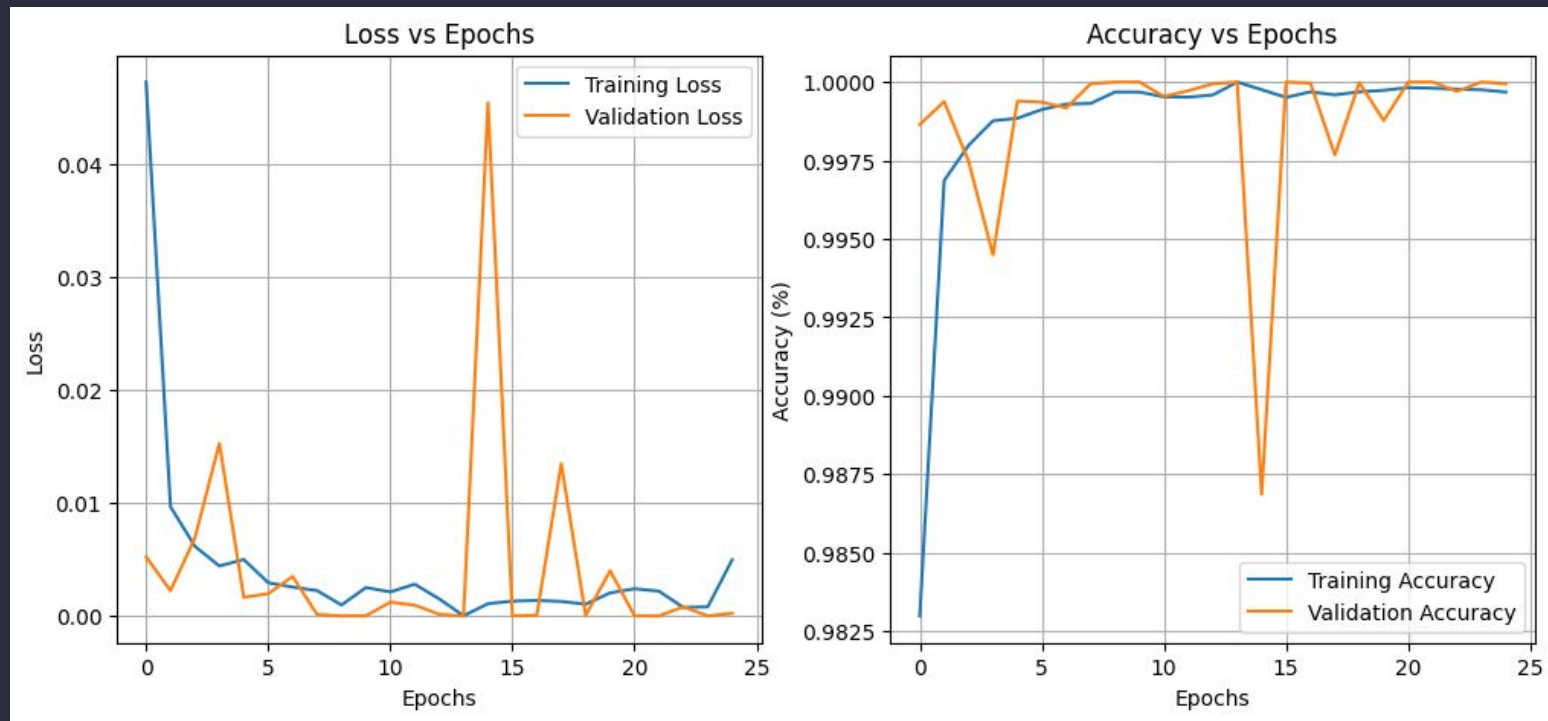
Modeling Pipeline: Training on Sequential

- Changed from the baseline model presented a few weeks earlier

- Even smaller dataset (approx. 200) with an 80-20 split for the training and validation sets.

- Modified from handling 3 classes to 4

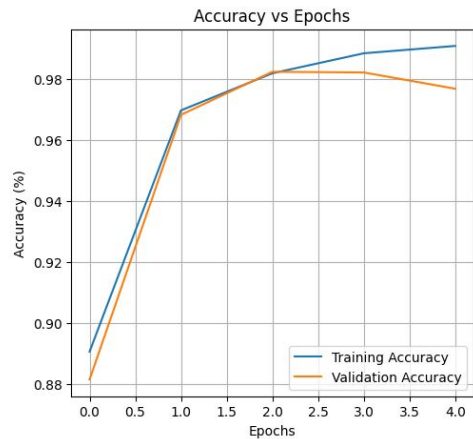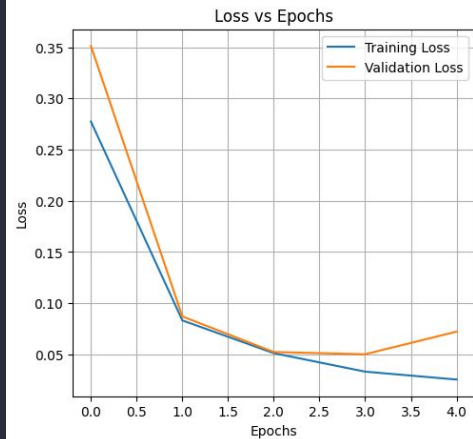- Class imbalance even worse than with the CNN-Model
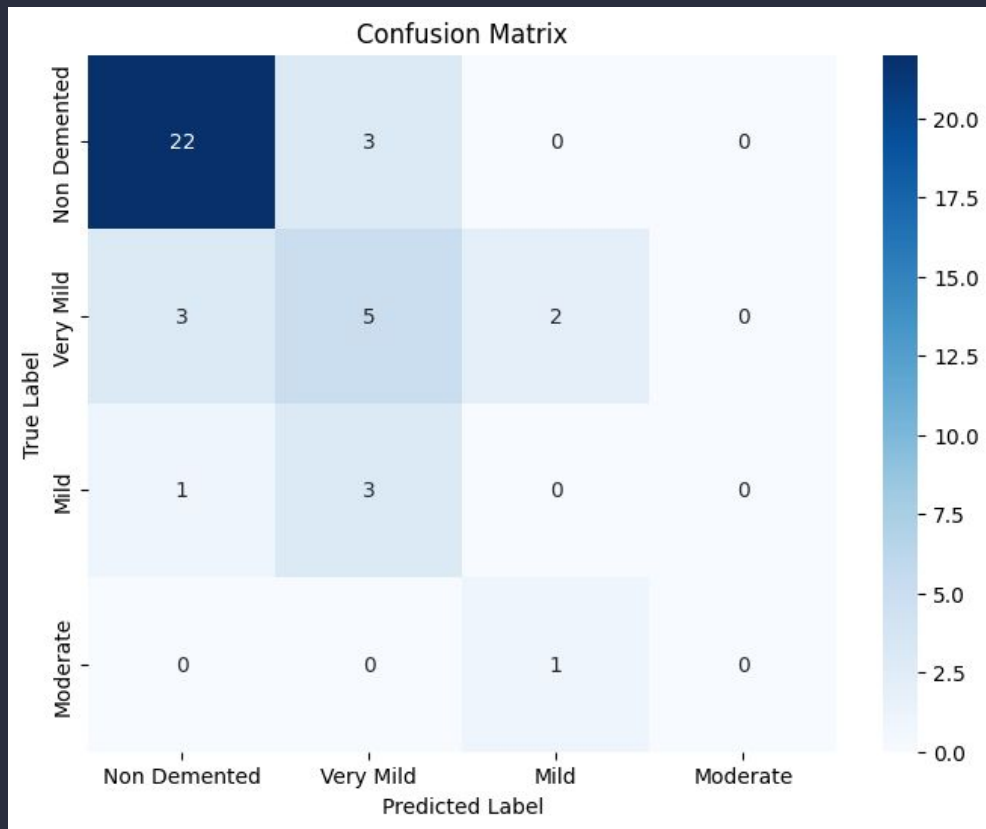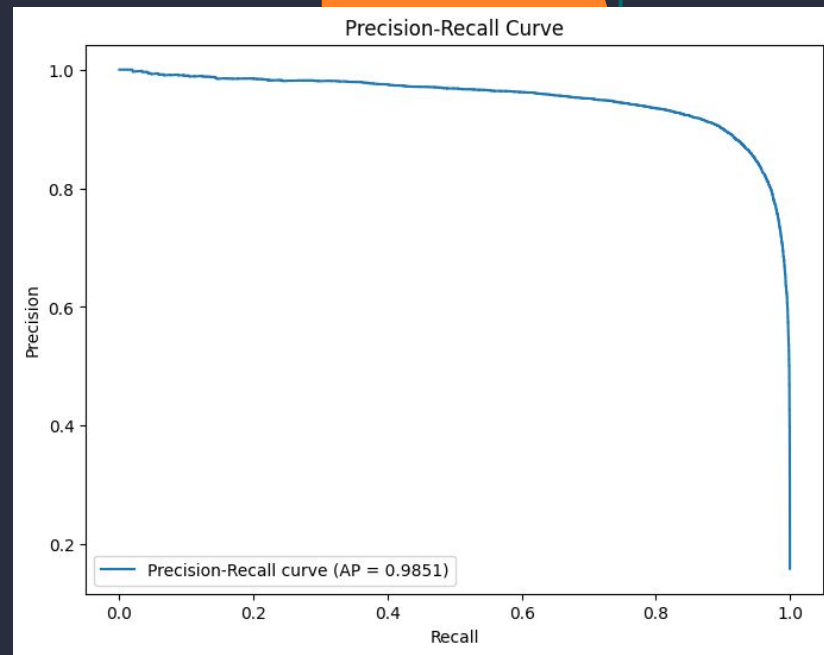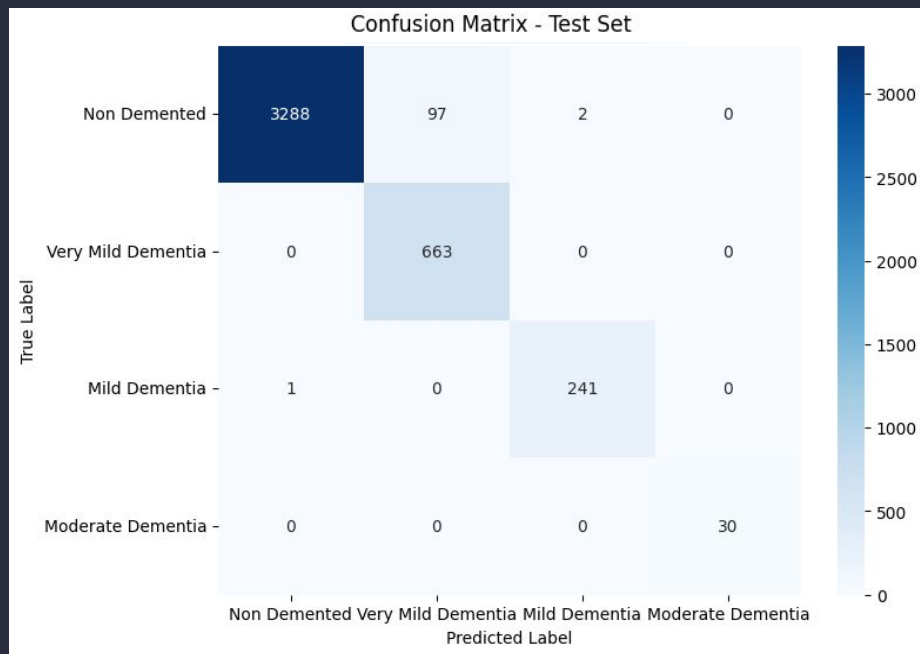
Confusion Matrix for Fusion Model
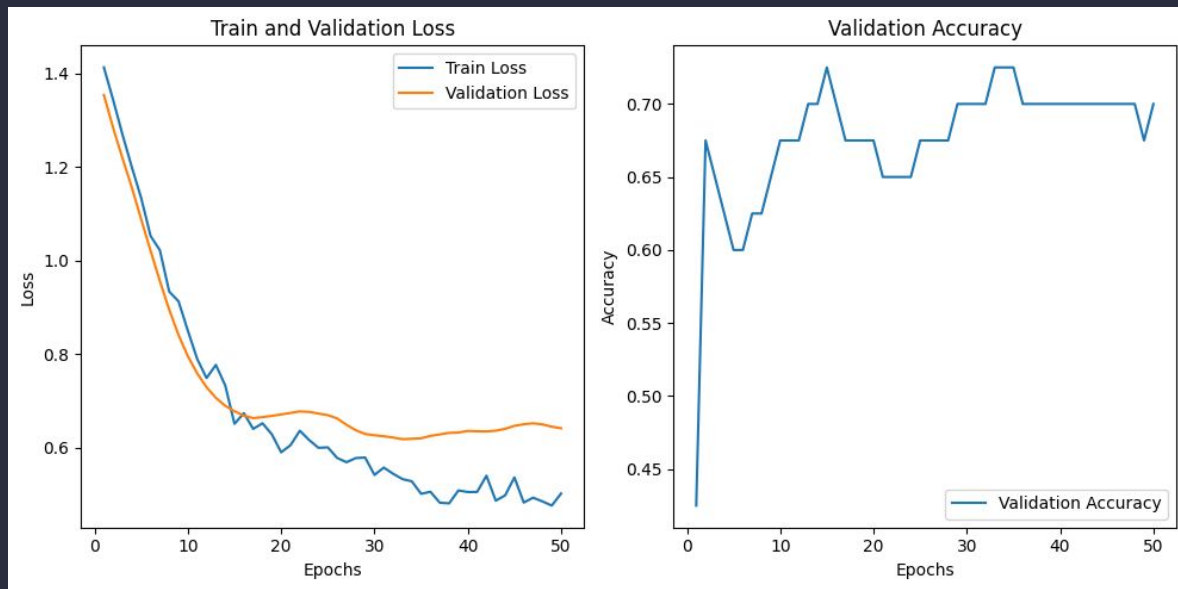
CNN-Model Training And Results

Results with ResNet-18

Confusion Matrix and PR Curve

Fusion Model Results

Training Losses and Validation Accuracy

Results with Sequential + SHAP

```
Classification Report on Validation Set:
              precision    recall  f1-score   support

Non Demented      0.85      0.88      0.86        25
   Very Mild      0.45      0.50      0.48        10
        Mild      0.00      0.00      0.00         4
    Moderate      0.00      0.00      0.00         1

    accuracy                          0.68        40
   macro avg      0.33      0.34      0.33        40
weighted avg      0.64      0.68      0.66        40
```

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Shapley Values (SHAP)

- A Partition Explainer is used as a heat map to explain predictions.

- Pink is for a positive correlation for that class/label

- Likewise, blue represents a negative correlation
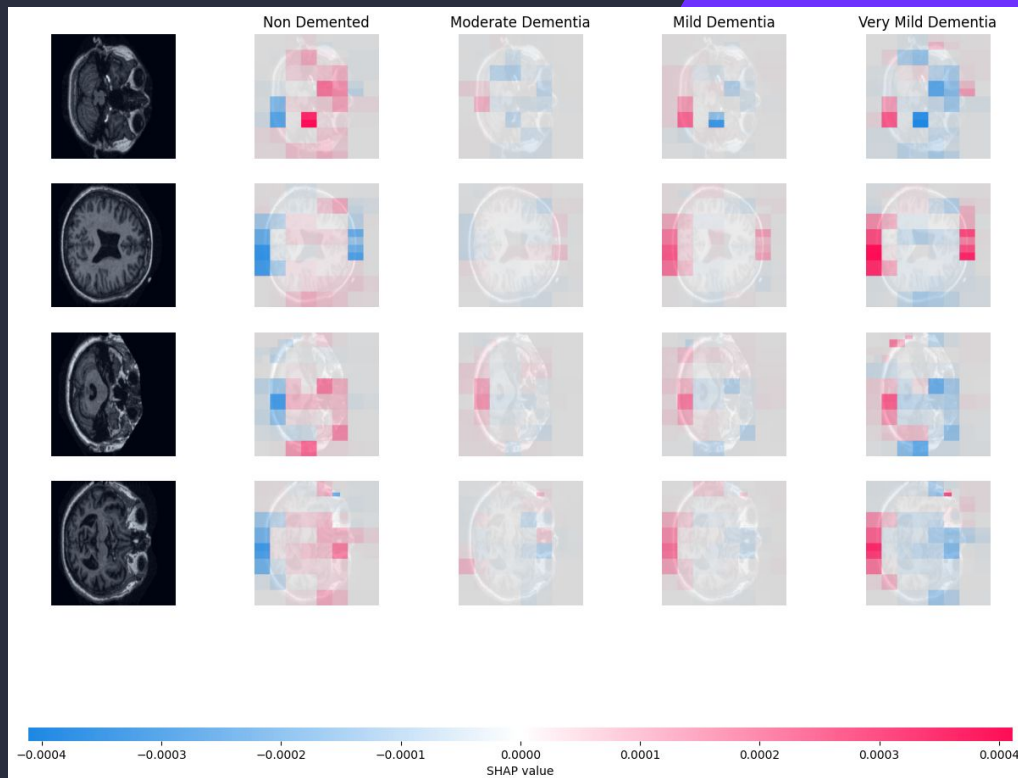
Conclusion

- ResNet-18 alone was enough to achieve 90%+ accuracy on different topics

- Data imbalances made predicting for certain Alzheimer's classes difficult

- This was resolved through the use of oversampling

- The resulting model is reliable in diagnosing Dementia at different stages

THE END

Have a good Summer!