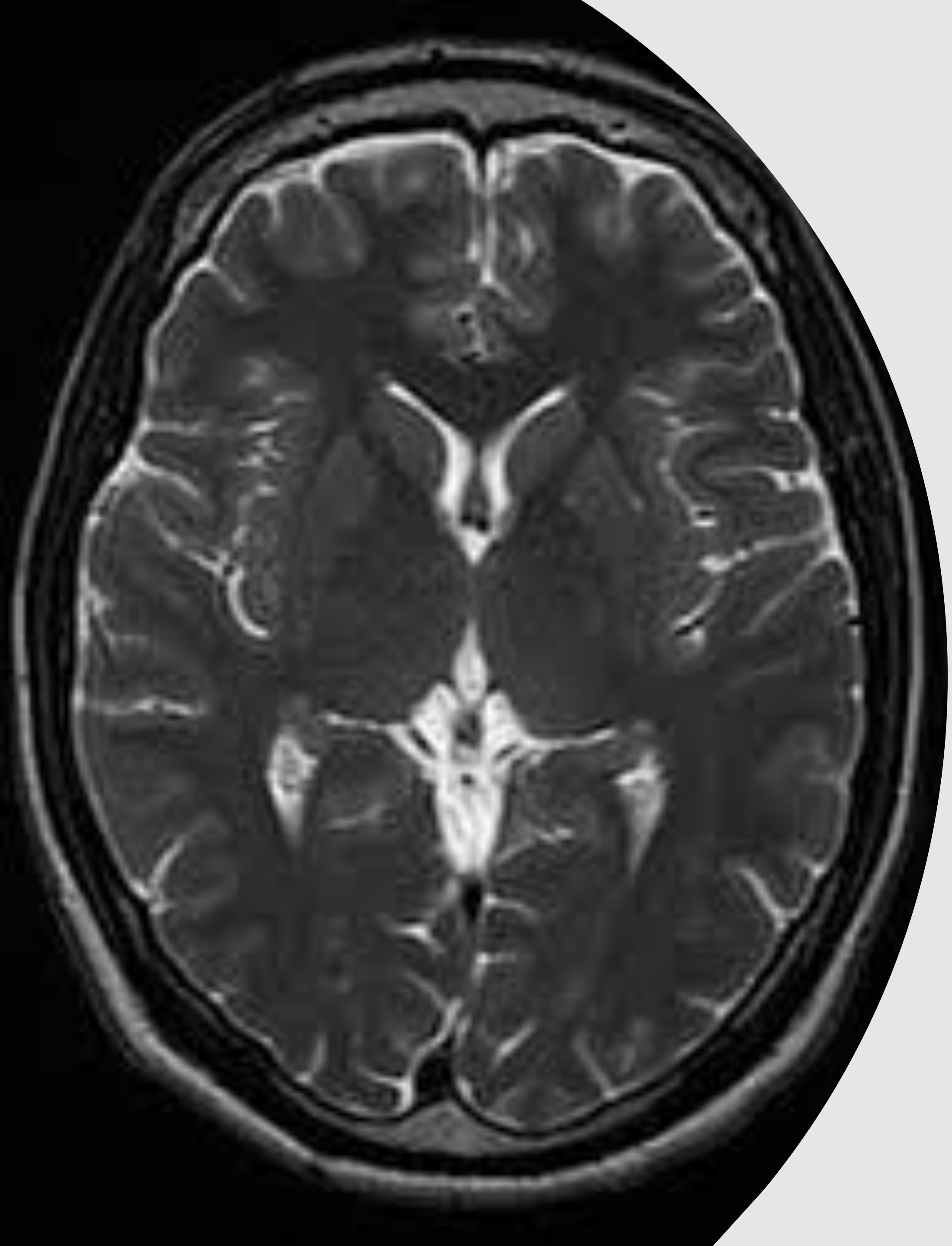

49275 Neural Networks and Fuzzy Logic

L10. DEMENTED AND NONDEMENTED BRAIN MRI IMAGES CLASSIFICATION

Seminar 2

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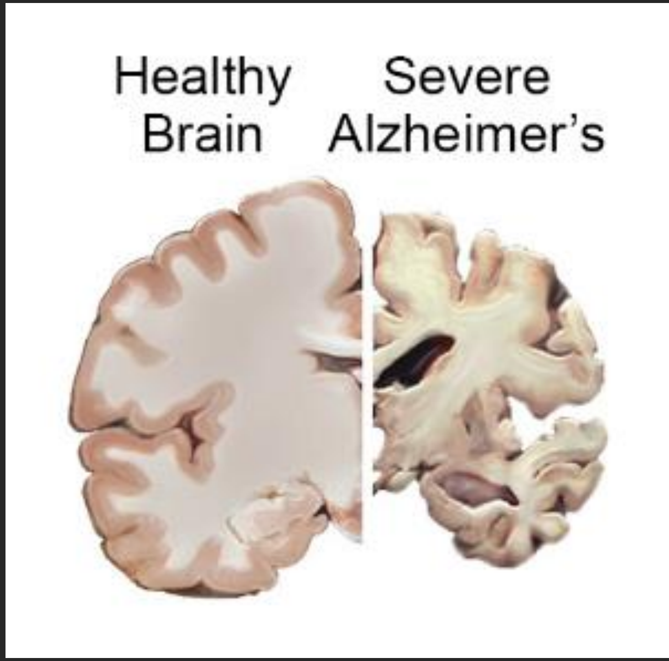
Project: Classification of Demented and Non-Demented Brains

- Focusing on implementing machine learning algorithms to assist in distinguishing patients with Alzheimer's Disease
- Future applications focuses on creating assistive devices for clinicians to utilize for supported diagnosis to achieve higher accuracy.
- This concept can be up-scaled to future endeavors focusing on early detection of Alzheimer's disease, which currently do not exist.



(National Institute on Aging, 2021)

Project Motivations

- Alzheimer's is the most common form of dementia
- No cure for the disease
- According to WHO, more than 55 million people live with dementia globally.
- "In 2019, the estimated total global societal cost of dementia was US$ 1.3 trillion, and these costs are expected to surpass US$ 2.8 trillion by 2030 as both the number of people living with dementia and care costs increase" (World Health Organisation, 2021)

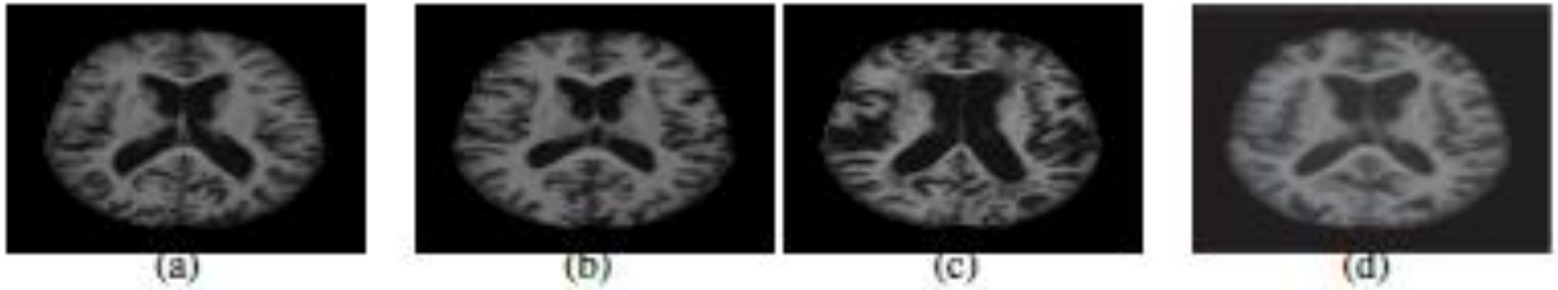


Figure 1: Example of different brain MRI images presenting different AD stage. (a) Nondemented; (b) very mild dementia ; (c) mild dementia; (d) moderate dementia.

Awate et al., 2018 figure 1.1

Aim / Objectives

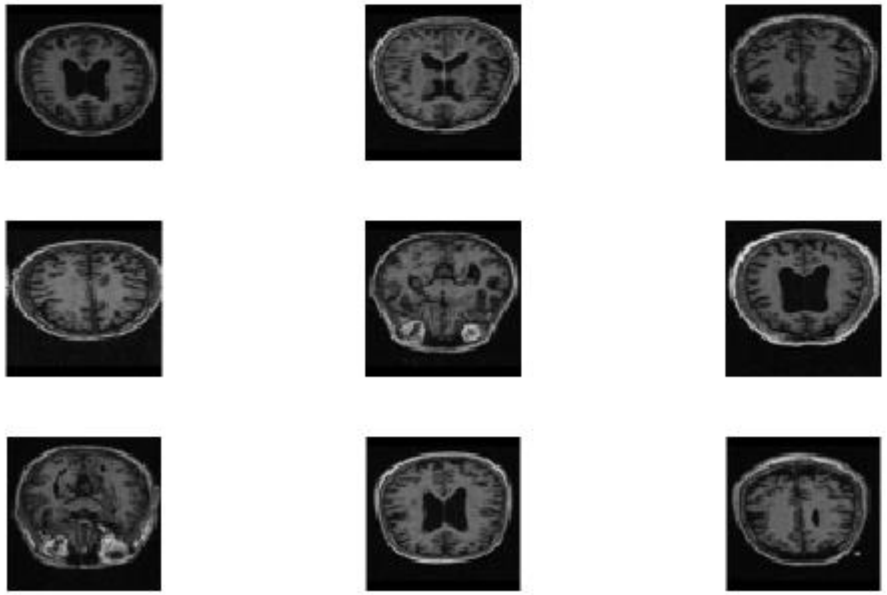
- Aim: Classification and prediction of demented and nondemented brain MRI using neural networks
- Ideal outcome: High accuracy (>90%) performing model, low variance and not overfitting.
- Objectives:
  - Pre-processing data to select most relevant features.
  - Create neural network capable of predicting patients likely to develop Alzheimer's disease.
  - Verify constantly model is not overfitting

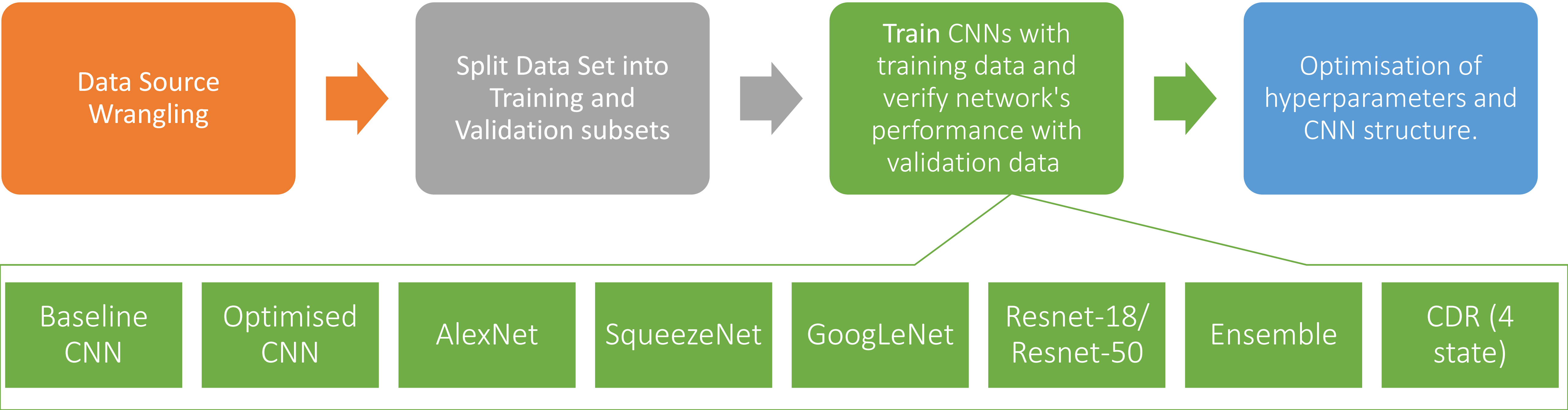
Methodology

- Converting MRI scans into computationally-feasible inputs (64x64 .bmp image files)
- Splitting OASIS-2 (373 MRI sessions | 150 Subjects) dataset into training and validation
- Evenly distributing Demented and Non-demented patients into training and validation sets.
- Implementing overfitting-controls to minimise likelihood of mis-representing accuracy of models.
- Development of various CNNs to classify patients.
- Optimising models to enhance performance, accuracy, and minimise loss.

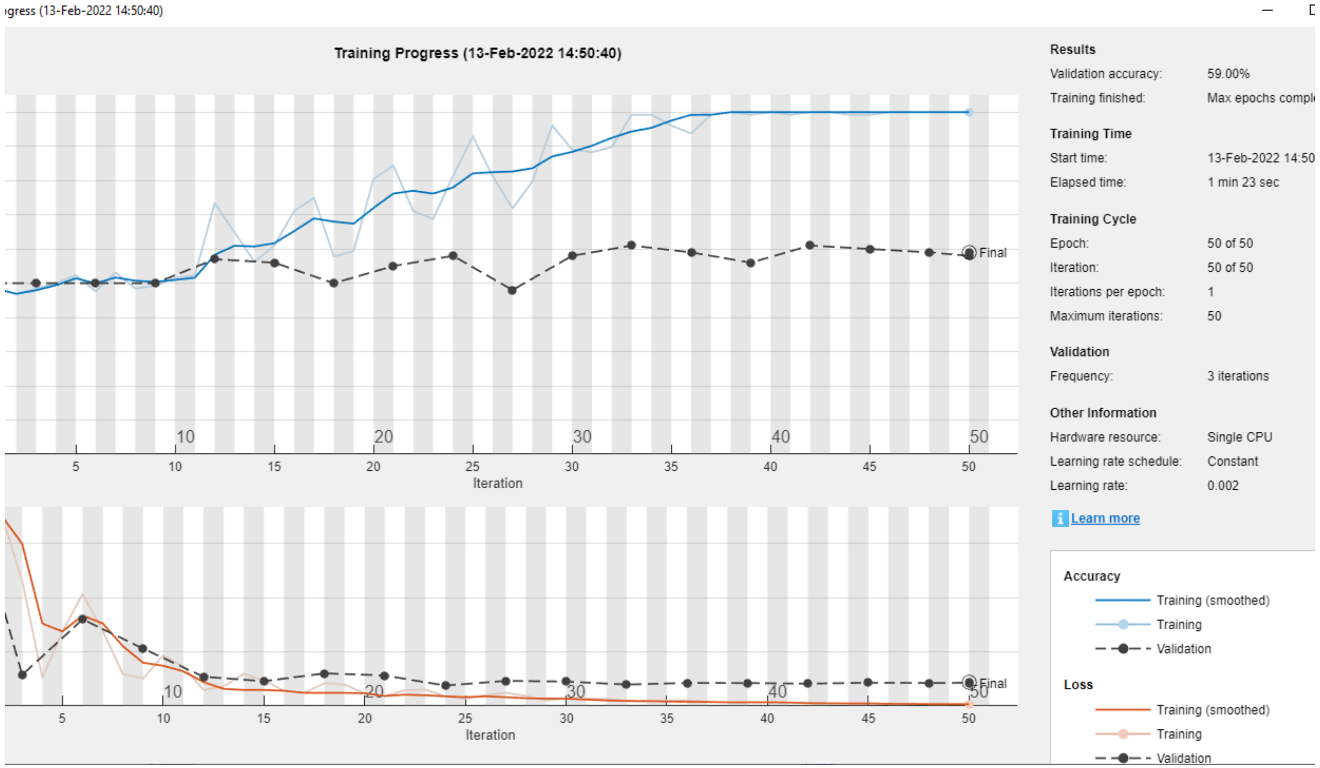
Functional Block Diagram

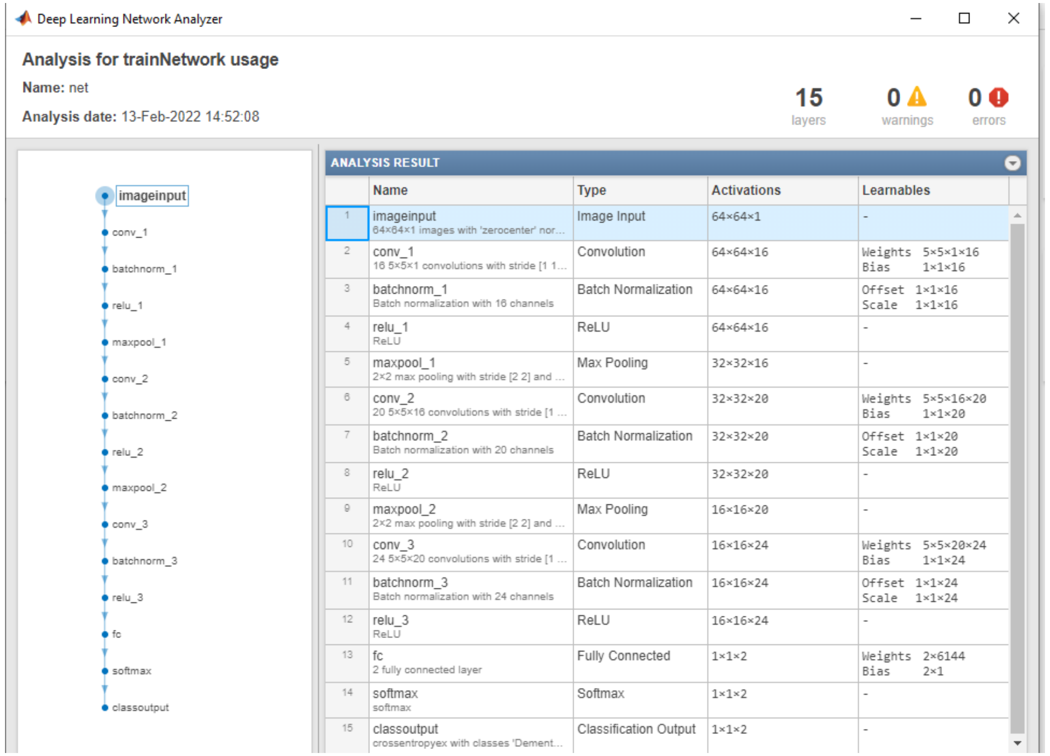
- Experiment with MRI Data from the OASIS Dataset
- Data pre-processing using MATLAB
- Nine models to evaluate: two basic CNN, five advanced CNNs, one ensemble model and one four state CNN





Experiment and Results: CNN Baseline (59% accuracy)





Experiment and Results: CNN Optimised *(68% accuracy)*

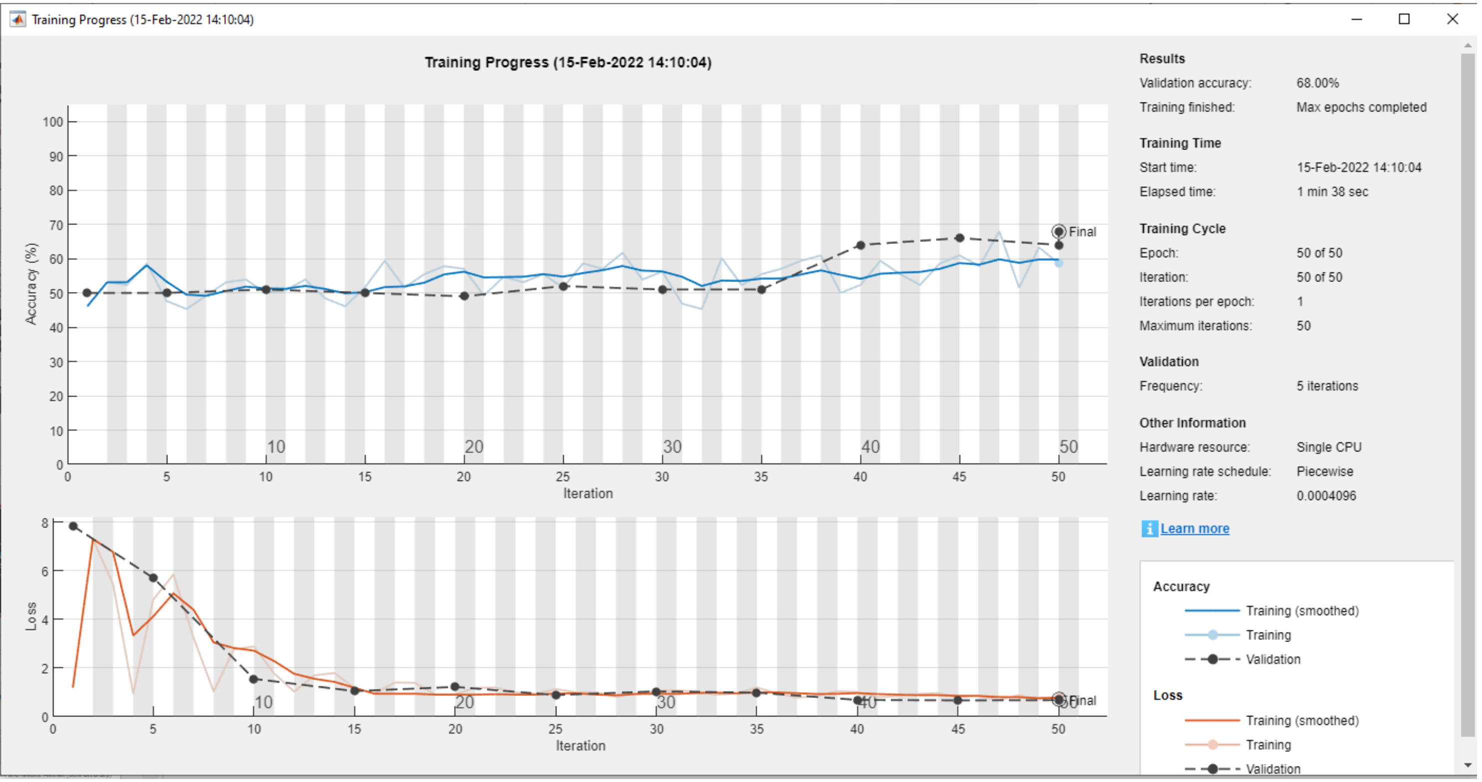
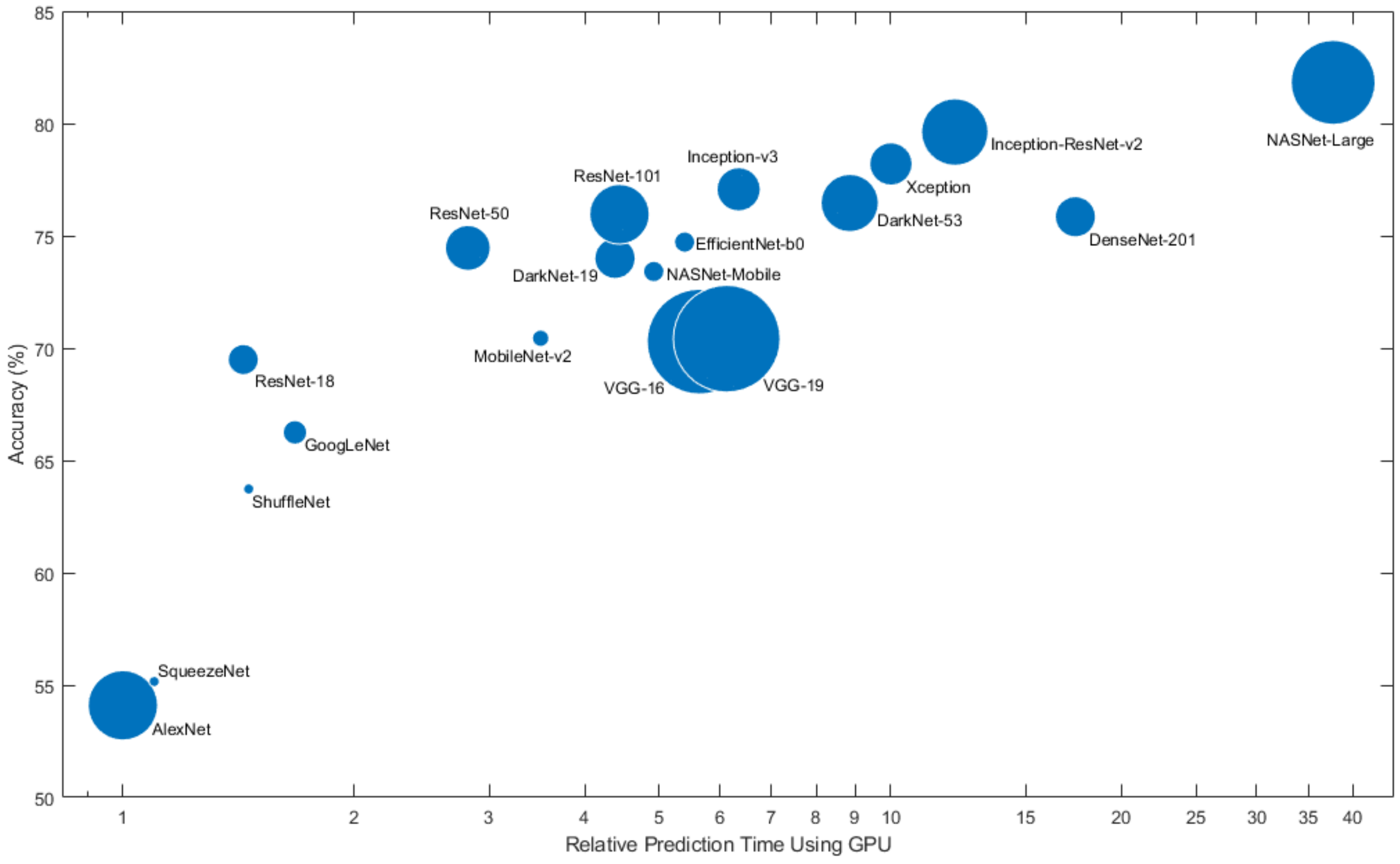


Table 2: CNN Layer Details (Baseline and Optimized)

Layer Description	Key Hyper-parameters	Size
Input Image Layer		64 * 64 * 1
Convolution Layer	X filters Baseline: 16 filters Optimised: 32 filters	64 * 64 * X
Batch Normalization Layer		64 * 64 * X
ReLU Layer		64 * 64 * X
Pooling Layer	Down sample by factor of 2	32 * 32 * X
Convolution Layer	Y filters Baseline: 16 filters Optimised: 32 filters	32 * 32 * Y
Batch Normalization Layer		32 * 32 * Y
ReLU Layer		32 * 32 * Y
Pooling Layer	Down sample by factor of 2	16 * 16 * Y
Convolution Layer	Z filters Baseline: 16 filters Optimised: 32 filters	16 * 16 * Z
Batch Normalization Layer		16 * 16 * Z
ReLU Layer		16 * 16 * Z
Fully Connected Layer	2 classes	1 * 1 * 2
Softmax Layer		1 * 1 * 2
Classification Layer		1 * 1 * 2

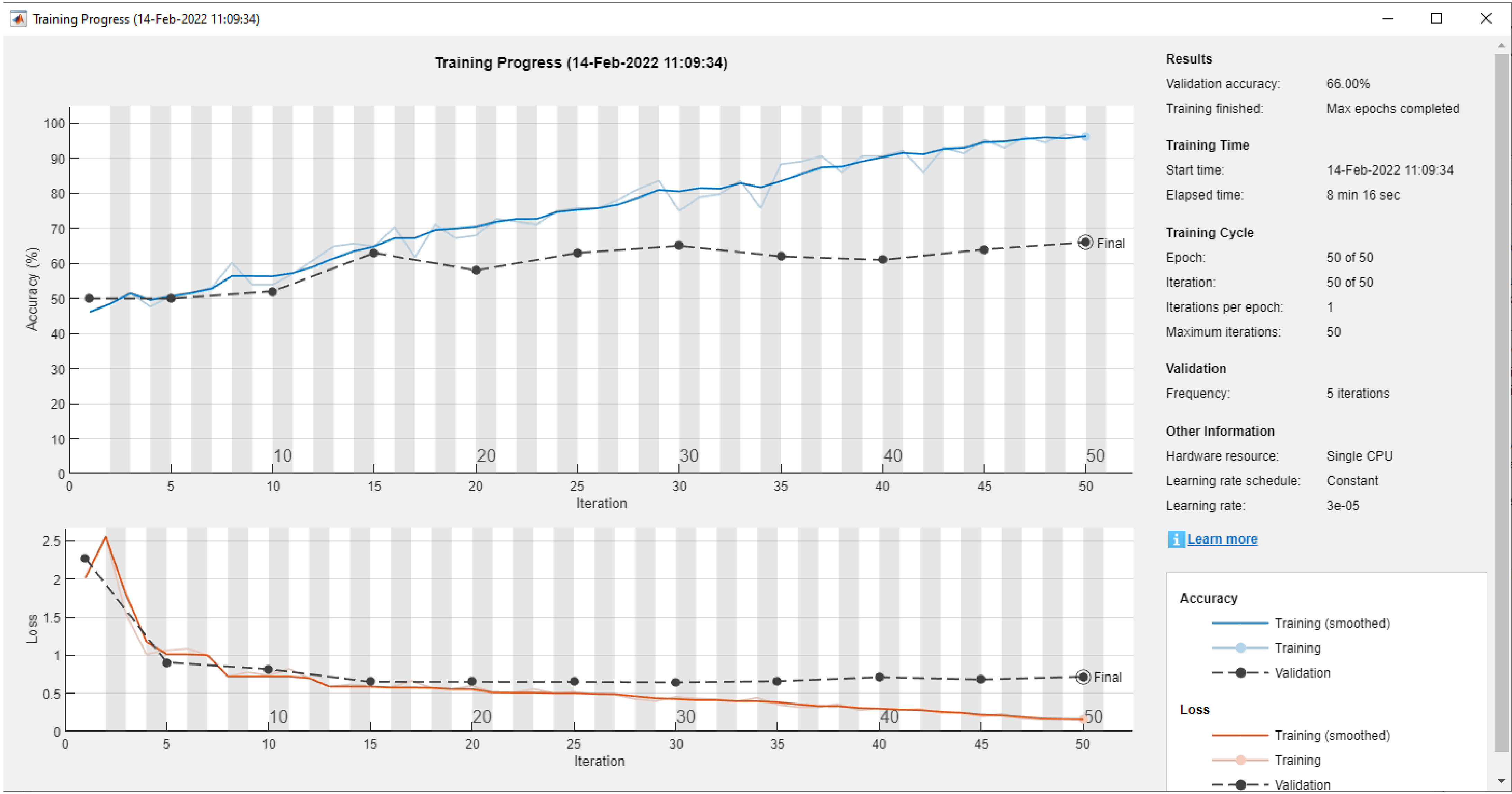
Advanced CNN Structures



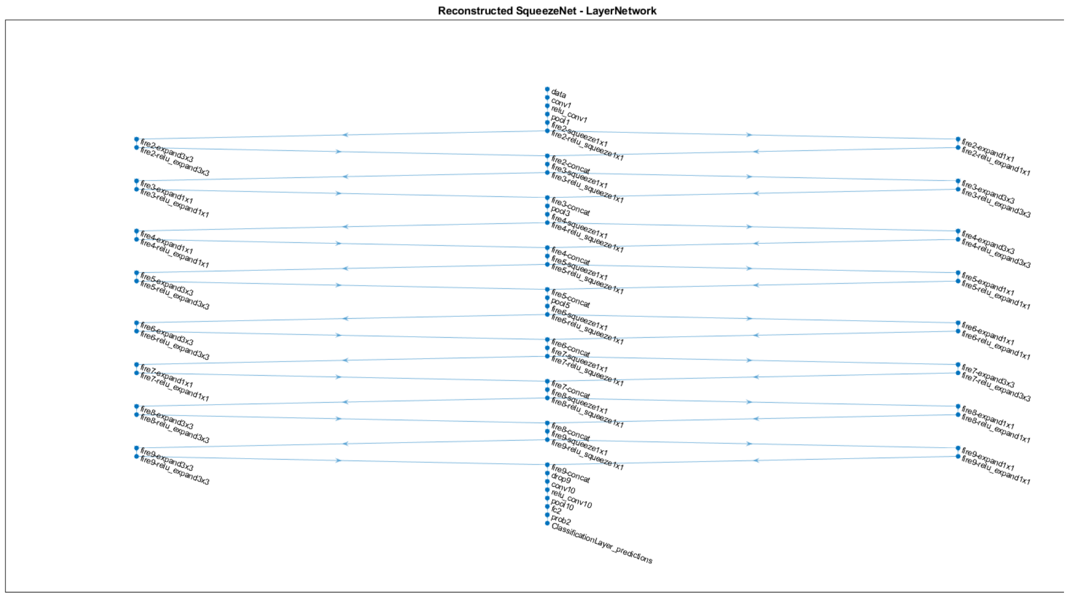
- Matlab has some built advanced CNN structures
- Require input image scaling (expect 227 pixel by 227 pixel with three colour channels) – use augmentedimagestore to adjust our training set
- Reconfigure classification layer to just two classes
- Use of dropout layers to avoid overfitting
- Train network

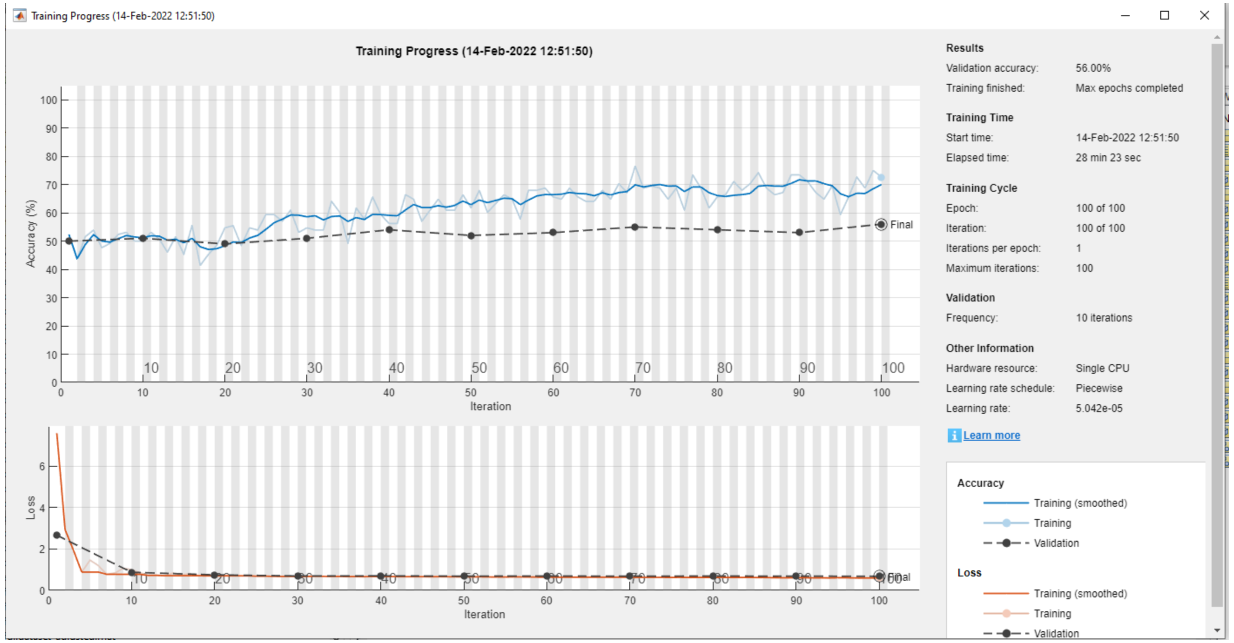
convolutional-neural-networks.html]

Experiment and Results: AlexNet *(66% accuracy)*

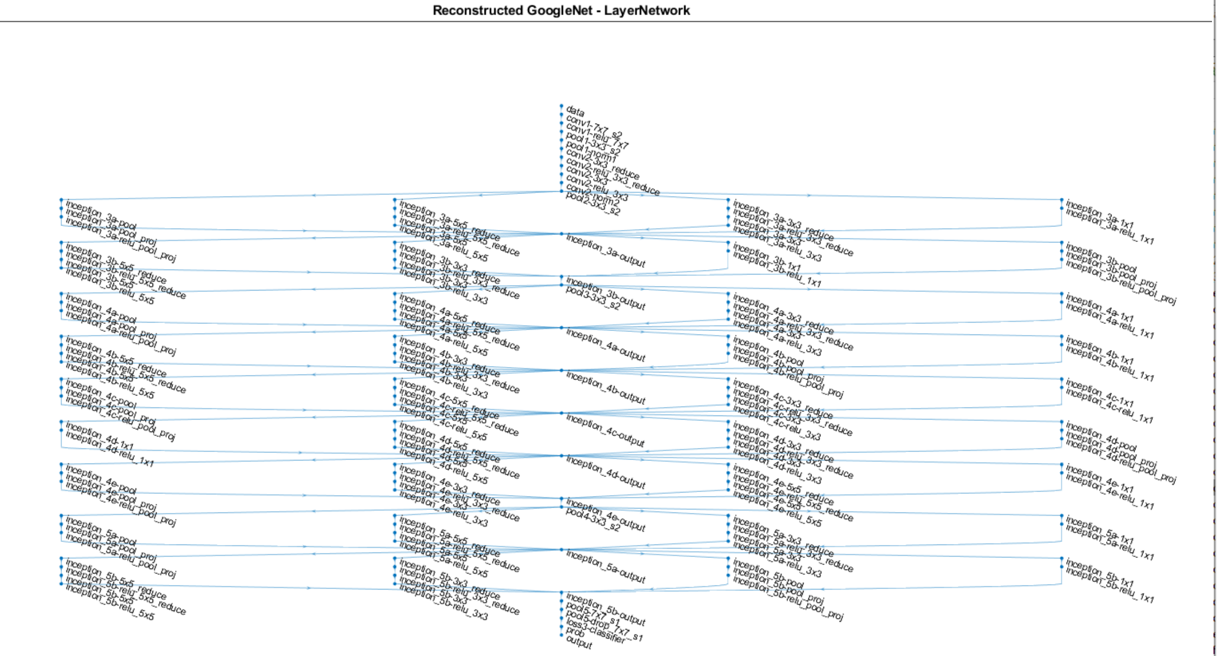


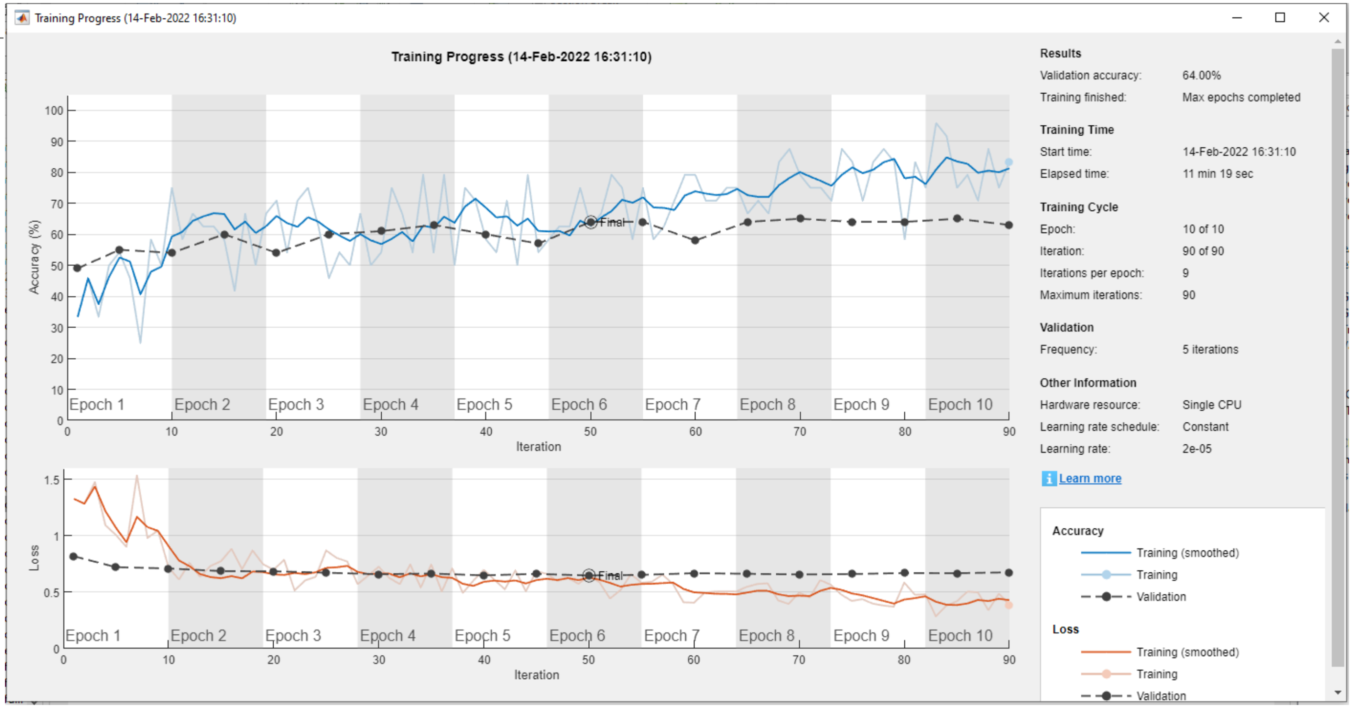
Experiment and Results: SquezeNet (56% accuracy)





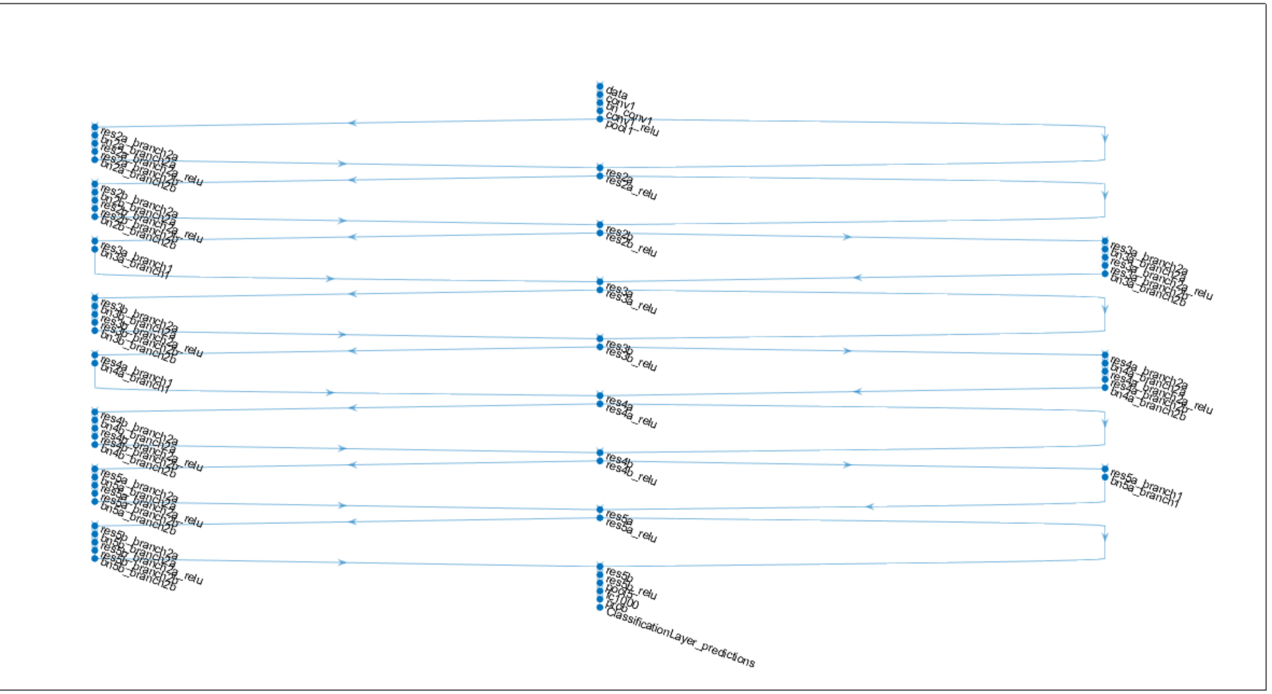
Experiment and Results: GoogLeNet *(64% accuracy)*

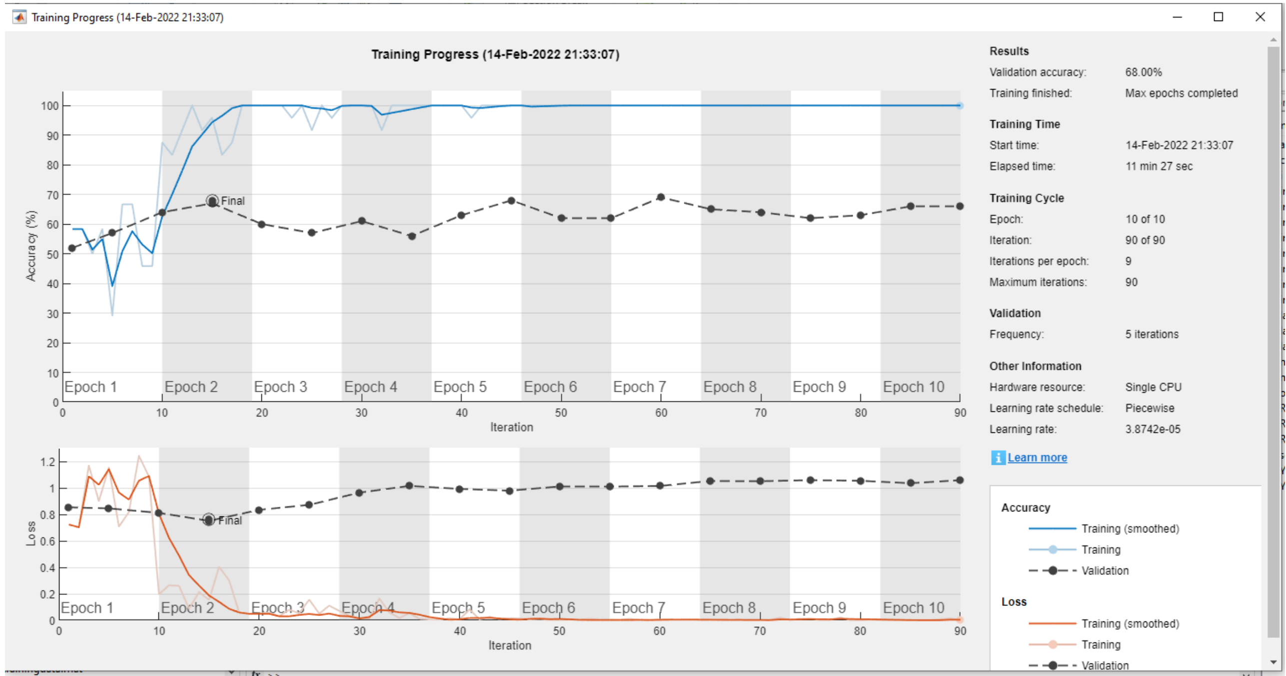




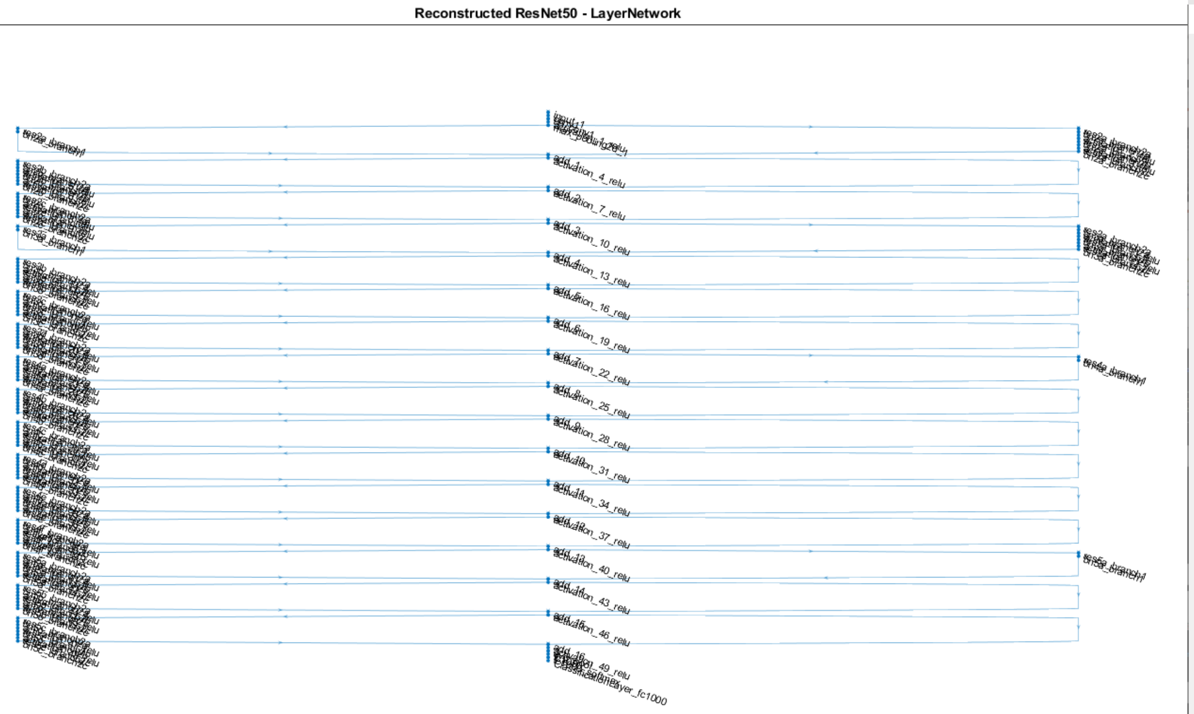
Experiment and Results: ResNet-18 *(68% accuracy)*

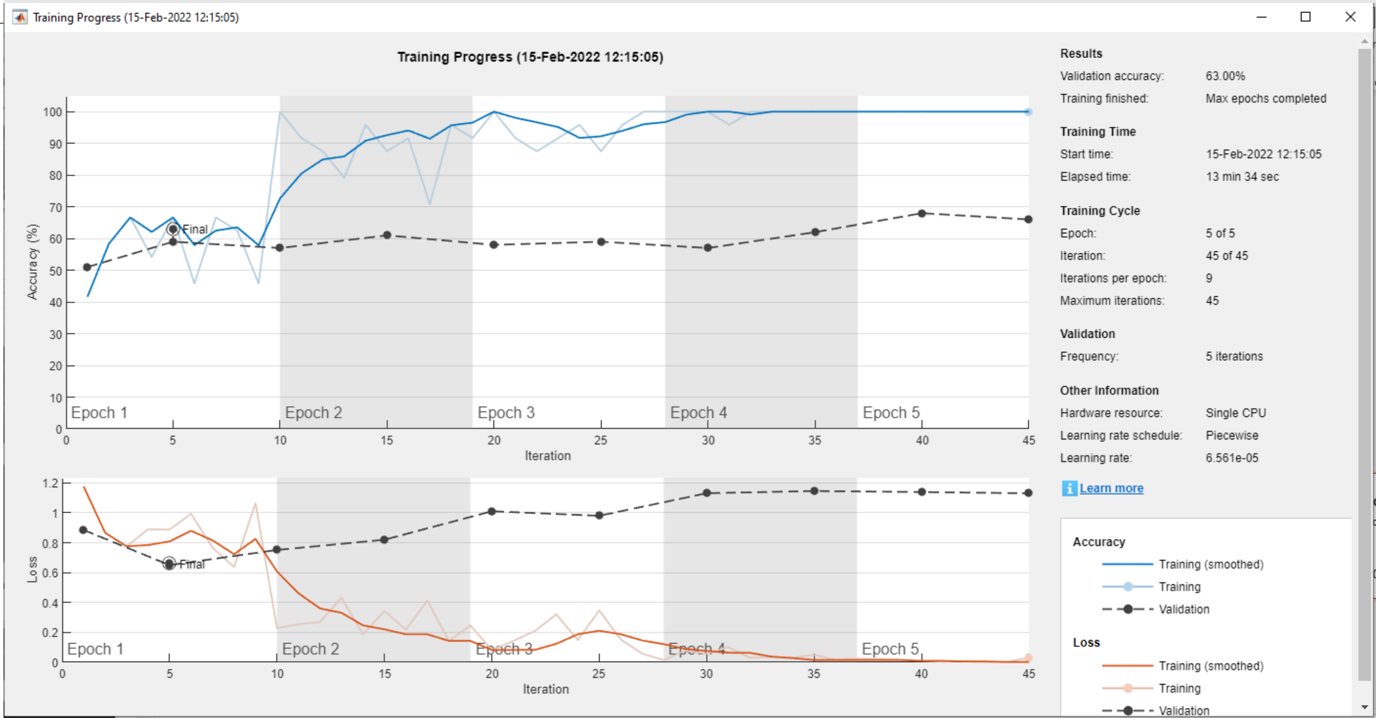
Reconstructed ResNet18 - LayerNetwork





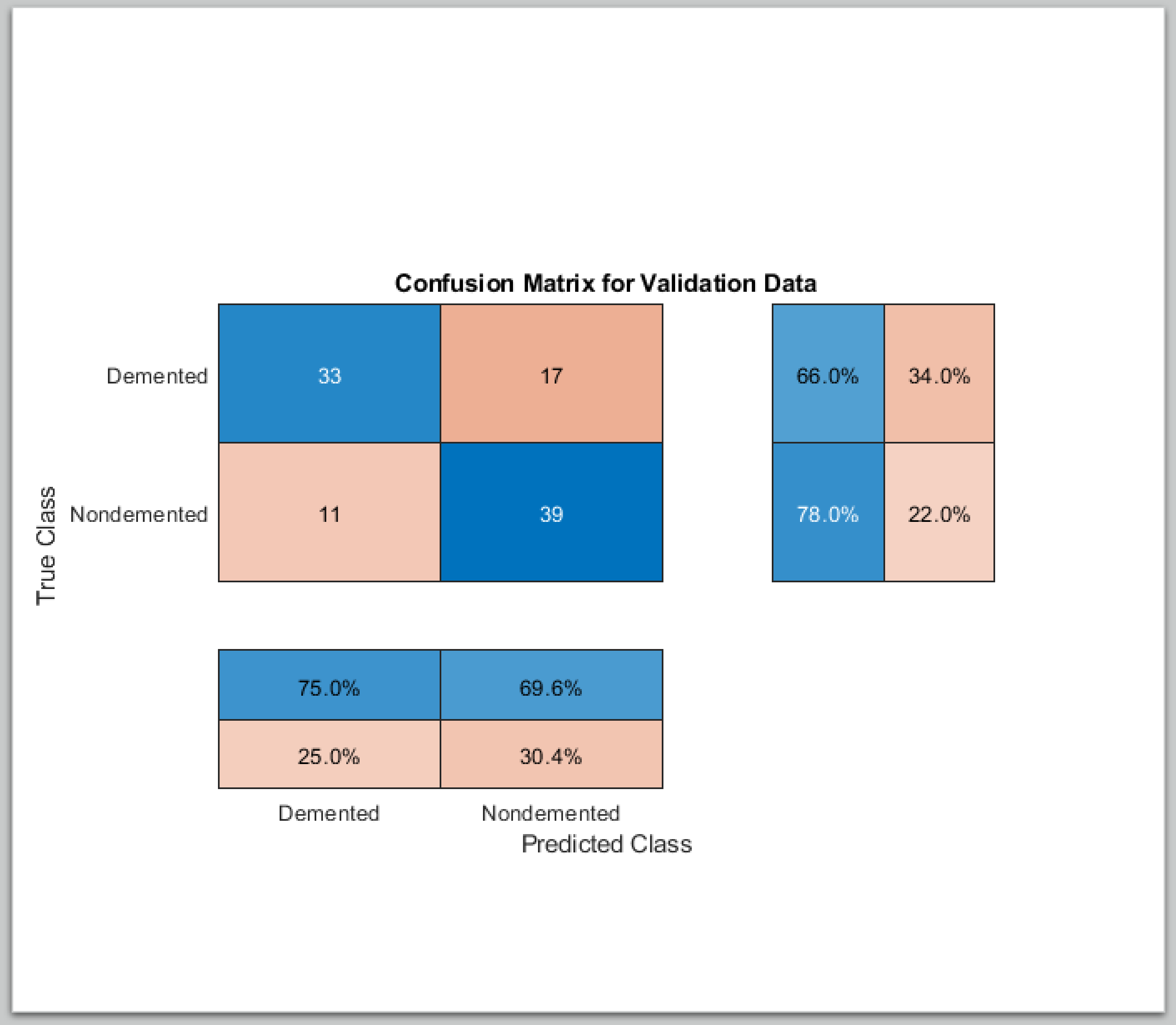
Experiment and Results: ResNet-50 *(63% accuracy)*





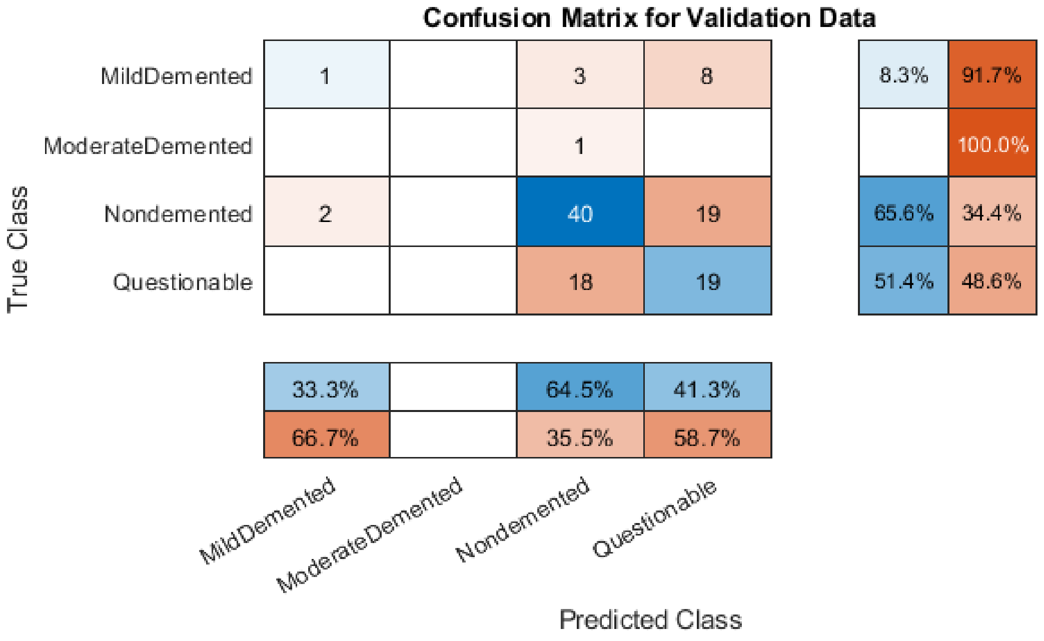
Experiment and Results: Ensemble Method
(72% accuracy)

1. Vote between multiple CNNs discussed above
2. Use the output softmax scores (% confidence)
3. Scale each network by a weight factor
4. Sum and normalise the different contributions
5. Analyse results



Experiment and Results: Four State CDR

54% accuracy (four clases)



Experiment and Results: Summary

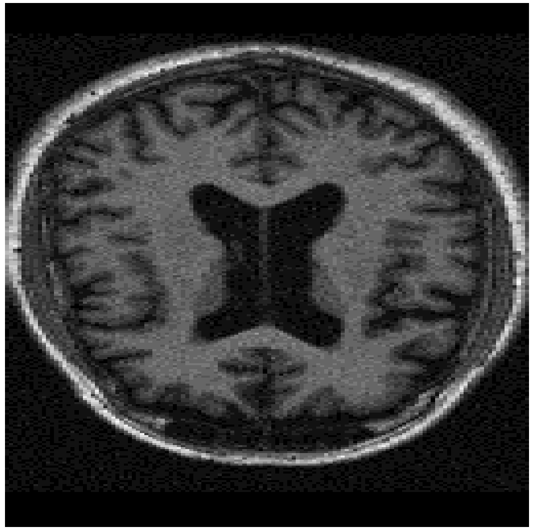
Model	# of Classes	Accuracy	Loss
Baseline CNN	2	59%	0.7552
Optimized CNN	2	68%	0.6822
SquezeNet	2	56%	0.6833
AlexNet	2	66%	0.7200
GoogLeNet	2	64%	0.6572
ResNet18	2	68%	0.7518
ResNet50	2	63%	0.6502
Ensemble	2	72%	N/A
CDR	4	54%	1.3537

Analysis and Discussion: Optimisation

- Training/Validation split ~ 70/30.
- Implementing imageDataAugmenter to implement rotations, pixel shifting, and reflections.
- Even distribution of Demented and Non-demented patients to ensure lack of biased classifications.
- Greater depth generally leads to higher performance, however Resnet-18 and Resnet-50 failed to demonstrate this leading to early halt of further development of Resnet-50.
- Average loss of models is 0.7, all networks achieved a loss within 1-2 standard deviations.

Analysis and Discussion: Limitations

- Training and validation split limited potential of models.
- Re-sizing images into 64x64 pixel .bmp image files resulting in lower resolution.
- Detailed features such as ventricles and hippocampus were unclear.
- Limited dataset size.



256x128 pixels

MRI scan of same patient

64x64 pixels

Conclusion

Best performing model was ensemble network.

Models could not achieve the 90% accuracy due to the limitations encountered during optimisation.

Limitations need to be addressed before future work can be continued.

Future work to improve performance

- Testing higher computational CNNs.
- Higher resolution input images.
- Better image pre-processing
- Larger dataset
- Interweaving multiple modalities.
  - Age.
  - Ethnicity.
  - Biomarkers: Derivatives of beta amyloid concentrations.
  - Genetics: TREM2.

Individual Project Contributions:

Yuk Leong

- Literature Review
- CNNs optimisation

Robert Makepeace

- Data wrangling
- CNN Experiments and Optimisation
- Advanced CNNs and optimisation
- Method

Sannjit Saha

- Feasibility

Reference

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