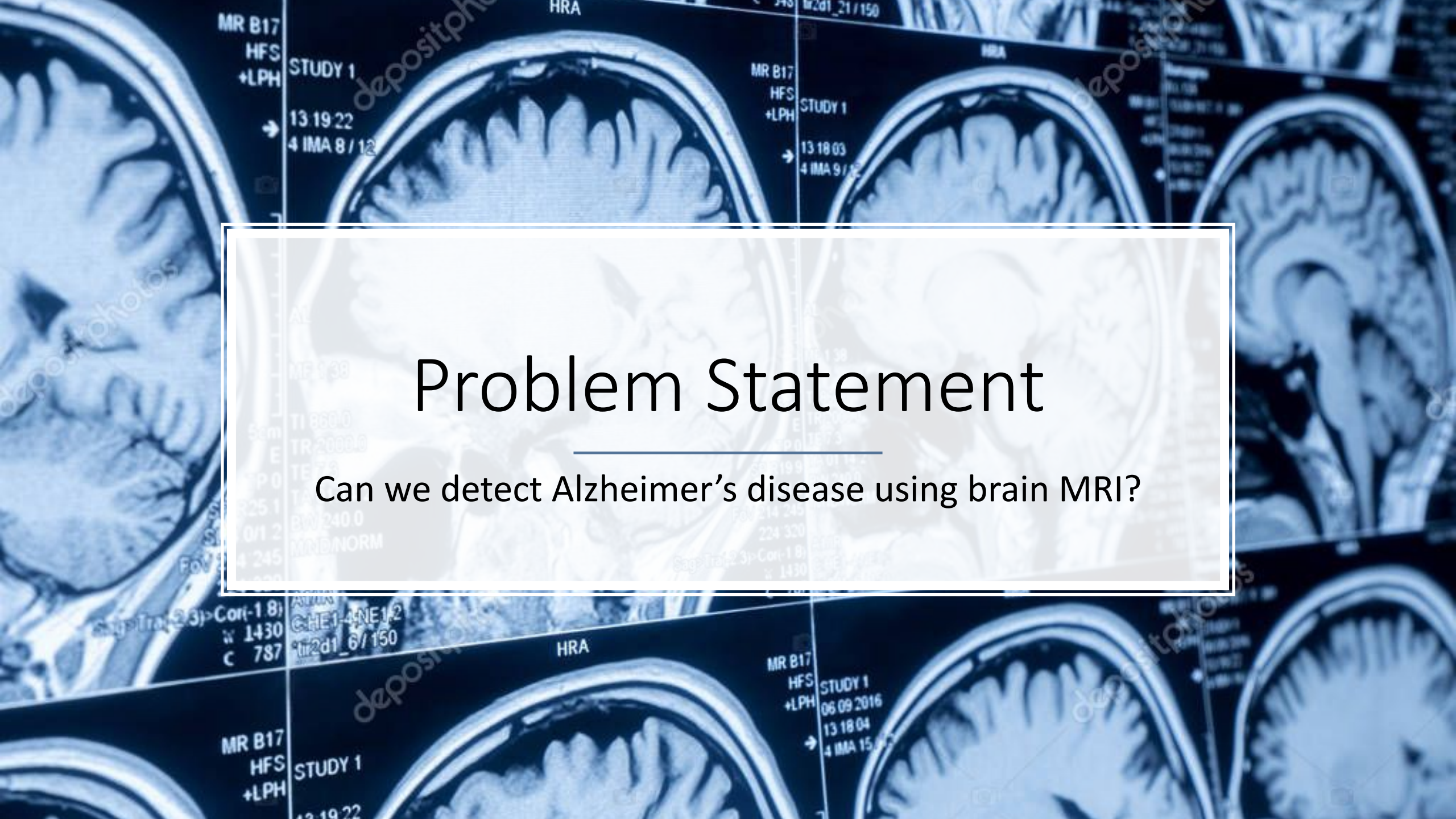
Predicting Alzheimer's Disease Using Brain MRI

Feras Altwal

Capstone Project

DSIR-824

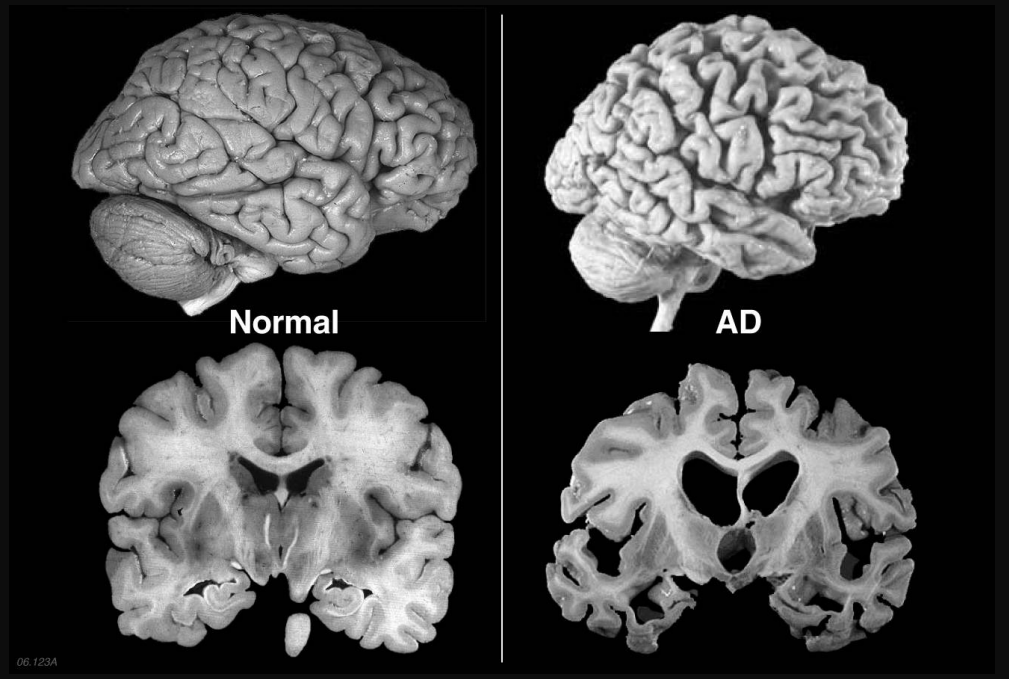


Problem Statement

Can we detect Alzheimer’s disease using brain MRI?

Alzheimer’s Disease (AD)

- Progressive neurodegenerative disease
- Affects memory, language, reasoning, social behavior
- Affects 44 million around the world, 5.5 million in the US

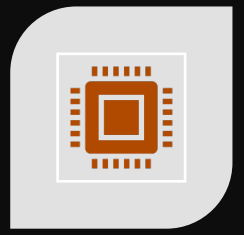


Project Pipeline

DATA COLLECTION

DATA VISUALIZATION

IMAGE PRE-PROCESSING

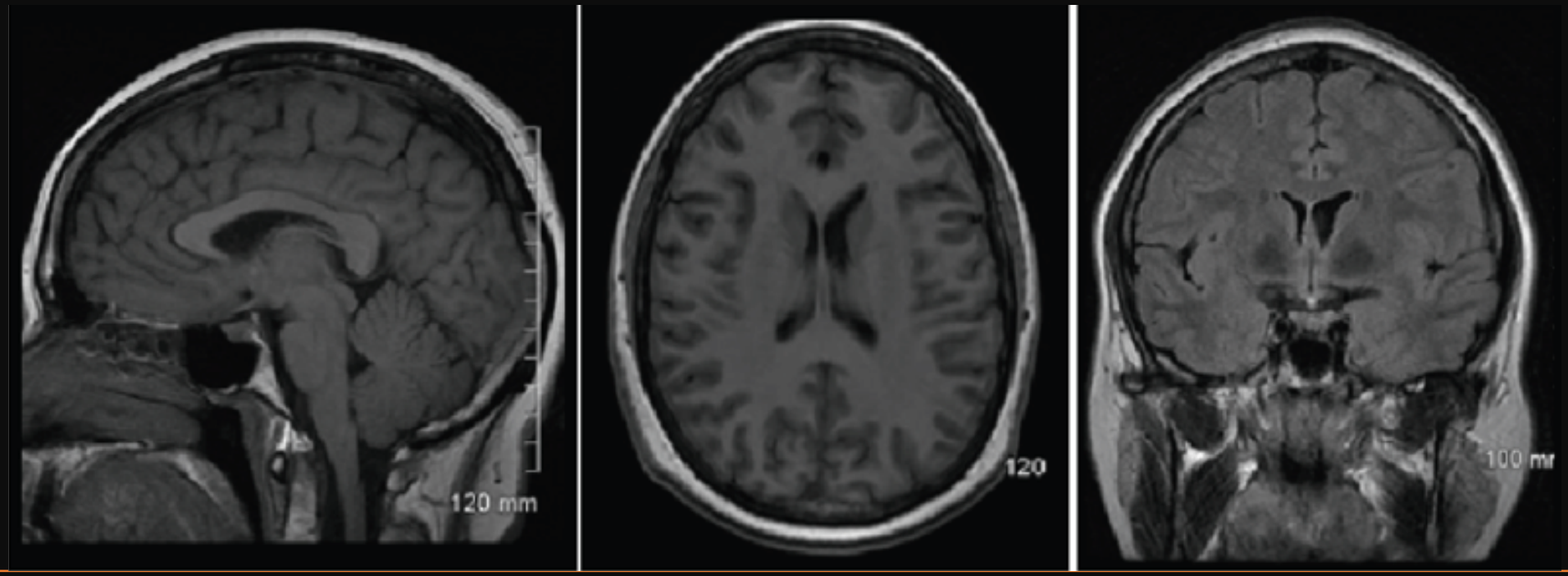


MODELING

INTERACTIVE MODEL

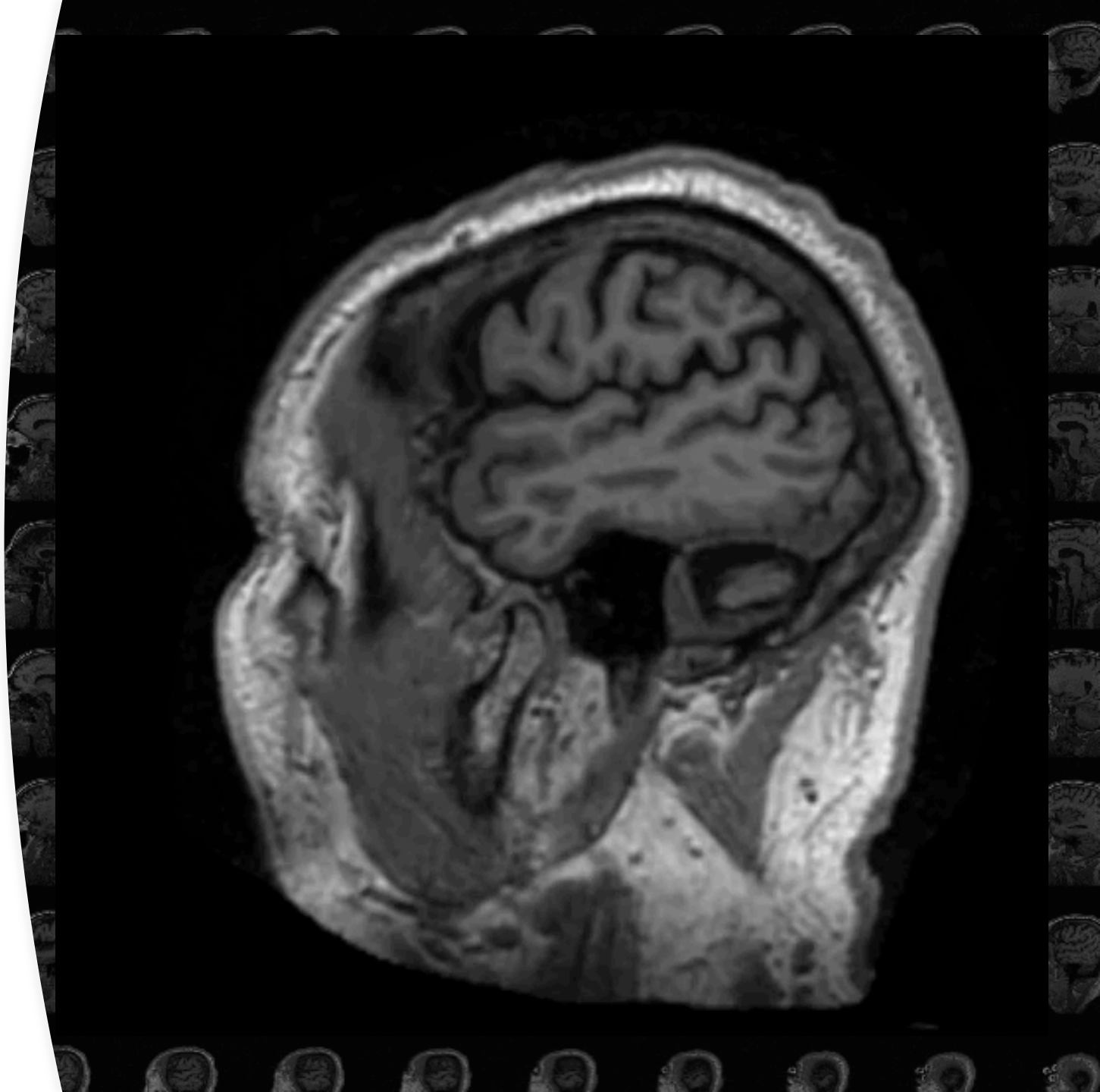
ADNI Dataset

- Alzheimer's Disease Neuroimaging Initiative (ADNI)
- Well-maintained collections of brain images (MRI, PET scans)



Dataset

- **T1-MRI images provided as NIFTI files**
- **NIFTI contains 160-170 images/ patient**
- **Patients:**
  - **AD: 117 subjects (~10K images)**
  - **CN: 137 subjects (~12K images)**



EDA

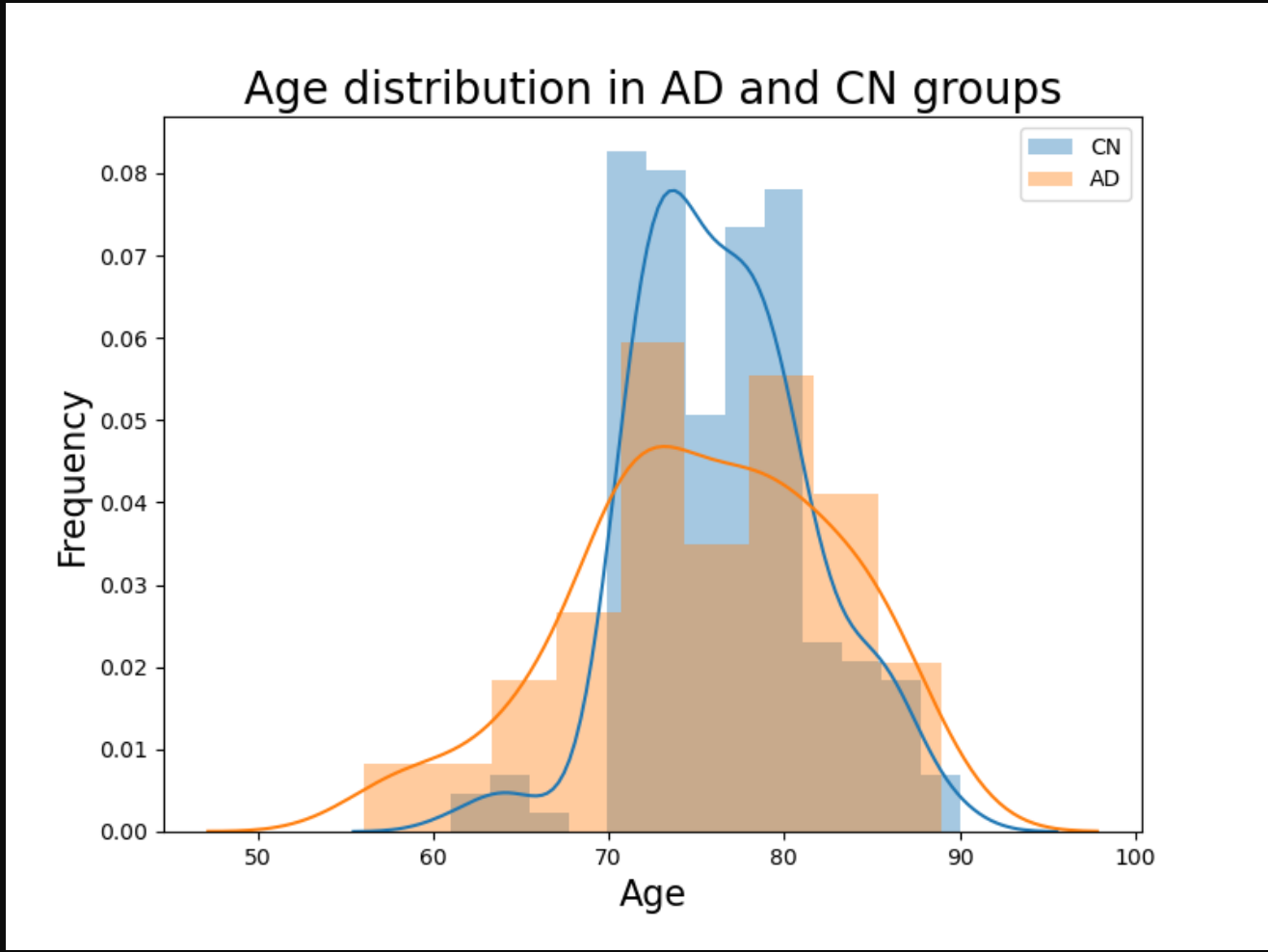

Age distribution in AD and CN groups
CN
AD
Frequency
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
50
60
70
80
90
100
Age

Image Processing

IMAGE EXTRACTION

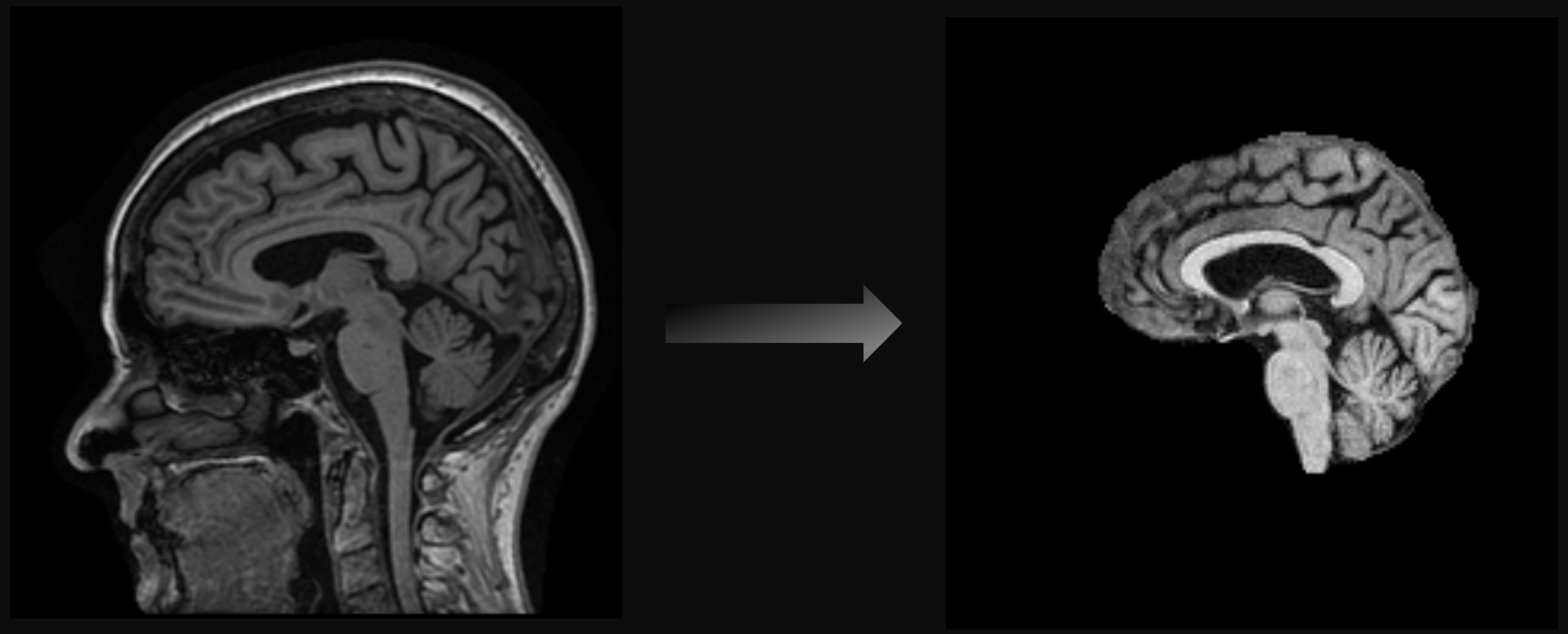
SKULL STRIPPING

RESIZING

GRAYSCALE

Image Processing

Skull stripping using a modified deepbrain library



Modeling

- Baseline model = ~50% accuracy
- Simple CNN model

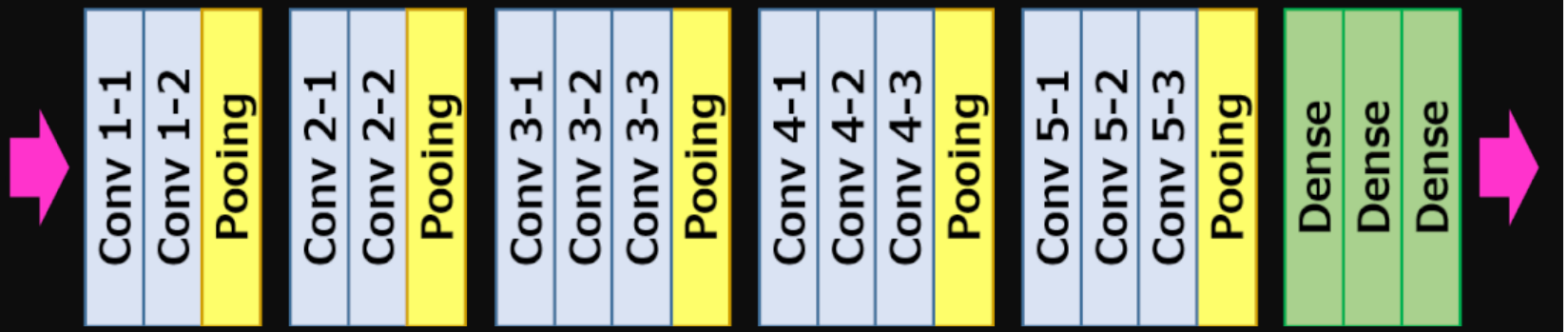
Layer (type)	Output Shape	Param #
conv2d_2 (Conv2D)	(None, 148, 148, 64)	640
max_pooling2d_2 (MaxPooling2	(None, 74, 74, 64)	0
dropout_1 (Dropout)	(None, 74, 74, 64)	0
conv2d_3 (Conv2D)	(None, 72, 72, 64)	36928
max_pooling2d_3 (MaxPooling2	(None, 36, 36, 64)	0
flatten_1 (Flatten)	(None, 82944)	0
dense_2 (Dense)	(None, 64)	5308480
dense_3 (Dense)	(None, 1)	65

Total params: 5,346,113
Trainable params: 5,346,113
Non-trainable params: 0

```
Epoch 1/5
91/91 [==============================] - 355s 4s/step - loss: 0.7270 - accuracy: 0.5432 - val_loss: 0.6822 - val_accuracy: 0.6017
Epoch 2/5
91/91 [==============================] - 342s 4s/step - loss: 0.6304 - accuracy: 0.6346 - val_loss: 0.5571 - val_accuracy: 0.7213
Epoch 3/5
91/91 [==============================] - 340s 4s/step - loss: 0.4894 - accuracy: 0.7612 - val_loss: 0.3985 - val_accuracy: 0.8257
Epoch 4/5
91/91 [==============================] - 337s 4s/step - loss: 0.3215 - accuracy: 0.8609 - val_loss: 0.2244 - val_accuracy: 0.9144
Epoch 5/5
91/91 [==============================] - 326s 4s/step - loss: 0.1691 - accuracy: 0.9345 - val_loss: 0.1263 - val_accuracy: 0.9568
```

Modeling

- TL model: VGG16



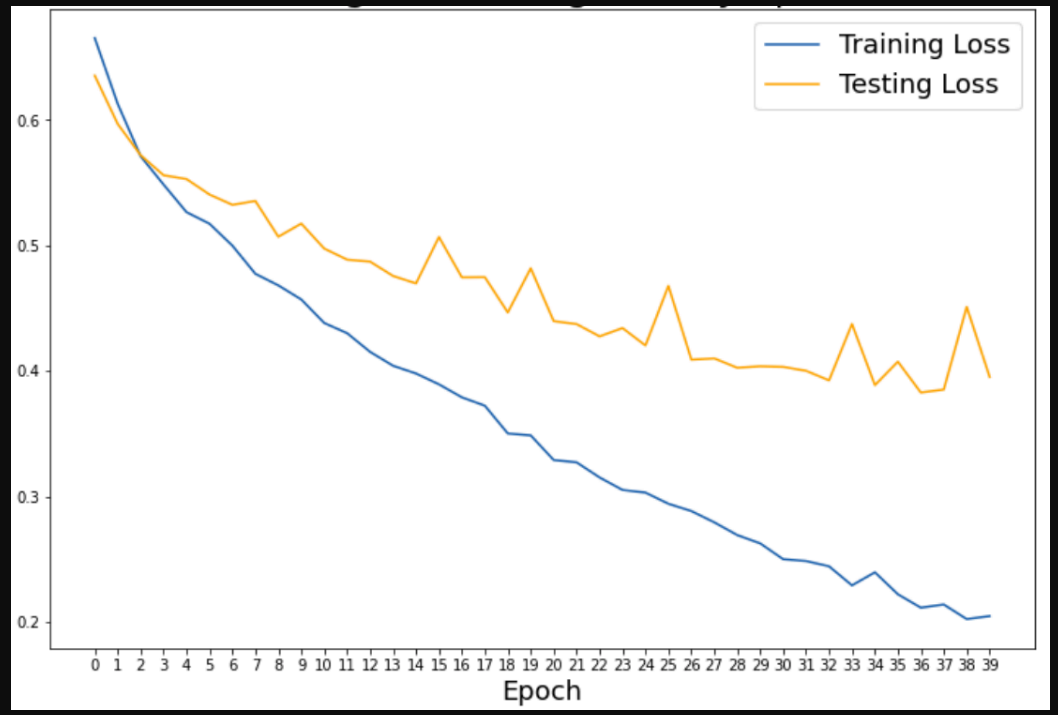

```
64/64 [==============================] - 8s 132ms/step - loss: 0.1883 - accuracy: 0.9347 - val_loss: 0.3538 - val_accuracy: 0.8525
Epoch 37/40
64/64 [==============================] - 8s 131ms/step - loss: 0.1826 - accuracy: 0.9375 - val_loss: 0.3614 - val_accuracy: 0.8325
Epoch 38/40
64/64 [==============================] - 8s 131ms/step - loss: 0.1761 - accuracy: 0.9402 - val_loss: 0.3481 - val_accuracy: 0.8481
Epoch 39/40
64/64 [==============================] - 8s 131ms/step - loss: 0.1639 - accuracy: 0.9491 - val_loss: 0.3535 - val_accuracy: 0.8506
Epoch 40/40
64/64 [==============================] - 8s 131ms/step - loss: 0.1706 - accuracy: 0.9427 - val_loss: 0.3461 - val_accuracy: 0.8556
```

Layer (type)	Output Shape	Param #
block1_conv1 (Conv2D)	(None, 150, 150, 64)	1792
block1_conv2 (Conv2D)	(None, 150, 150, 64)	36928
block1_pool (MaxPooling2D)	(None, 75, 75, 64)	0
block2_conv1 (Conv2D)	(None, 75, 75, 128)	73856
block2_conv2 (Conv2D)	(None, 75, 75, 128)	147584
block2_pool (MaxPooling2D)	(None, 37, 37, 128)	0
block3_conv1 (Conv2D)	(None, 37, 37, 256)	295168
block3_conv2 (Conv2D)	(None, 37, 37, 256)	590080
block3_conv3 (Conv2D)	(None, 37, 37, 256)	590080
block3_pool (MaxPooling2D)	(None, 18, 18, 256)	0
block4_conv1 (Conv2D)	(None, 18, 18, 512)	1180160
block4_conv2 (Conv2D)	(None, 18, 18, 512)	2359808
block4_conv3 (Conv2D)	(None, 18, 18, 512)	2359808
block4_pool (MaxPooling2D)	(None, 9, 9, 512)	0
block5_conv1 (Conv2D)	(None, 9, 9, 512)	2359808
block5_conv2 (Conv2D)	(None, 9, 9, 512)	2359808
block5_conv3 (Conv2D)	(None, 9, 9, 512)	2359808
block5_pool (MaxPooling2D)	(None, 4, 4, 512)	0
flatten (Flatten)	(None, 8192)	0
dense (Dense)	(None, 128)	1048704
dense_1 (Dense)	(None, 64)	8256
dense_2 (Dense)	(None, 1)	65

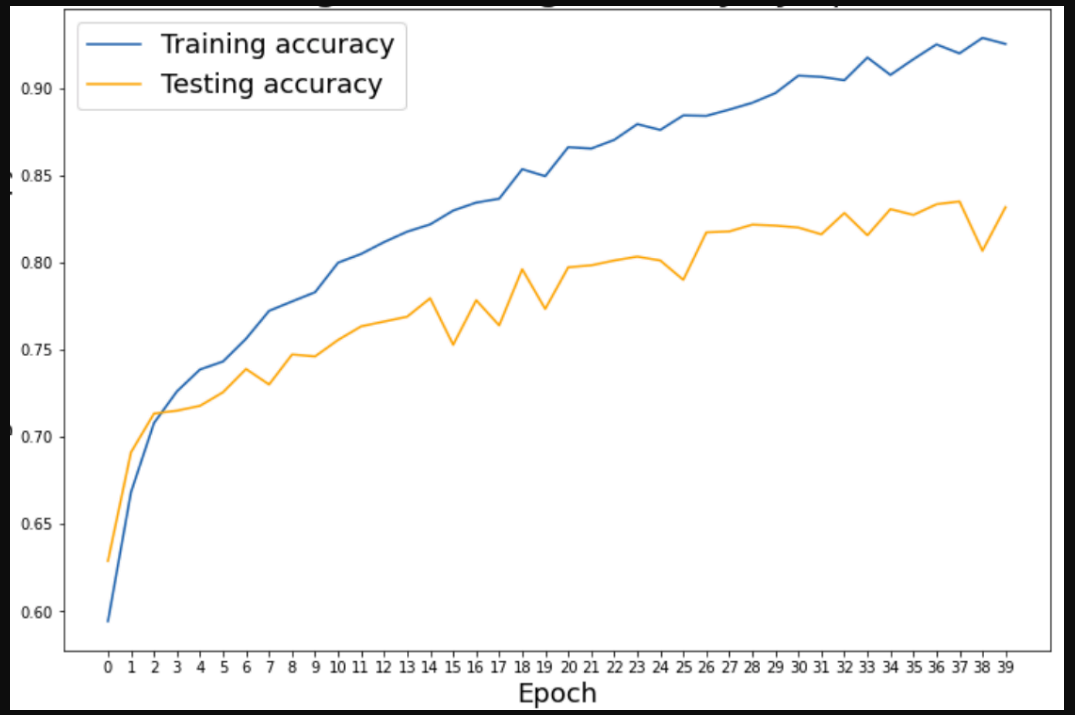
Total params: 15,771,713
Trainable params: 1,057,025
Non-trainable params: 14,714,688

VGG16 model metrics

Loss by epoch



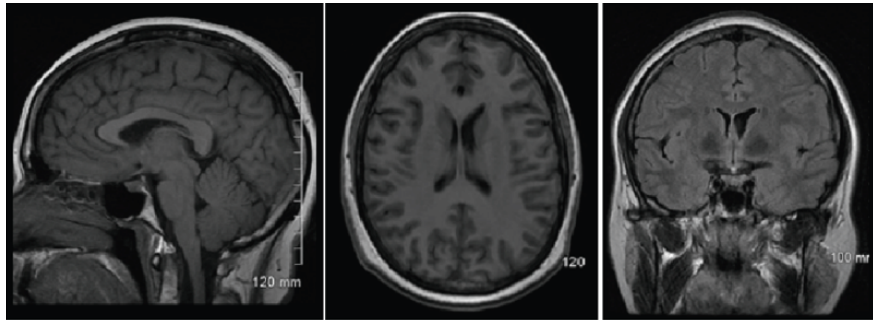
Accuracy by epoch

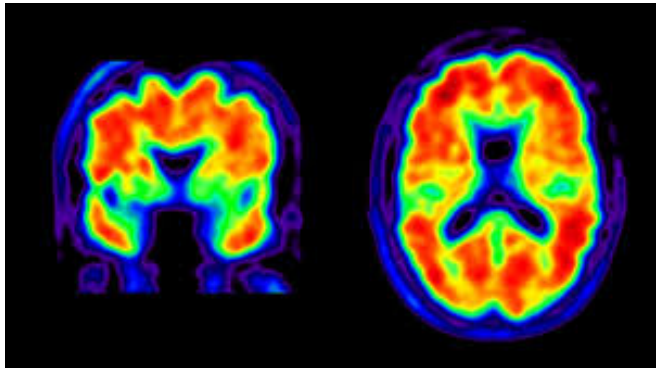


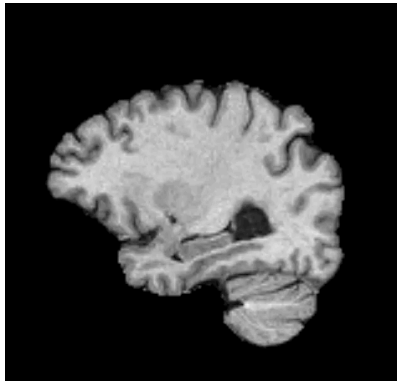
Interactive Model

Conclusion & Future Directions

- VGG16 model performed the best
- More modalities (coronal and axial MRI, PET scans)
- More image pre-processing
- CONV3D
- Try other TL models
- Classify pre-stages of AD (MCI)







Questions?