MRI IMAGE ANALYSIS FOR ALZHEIMER'S DISEASE PREDICTION

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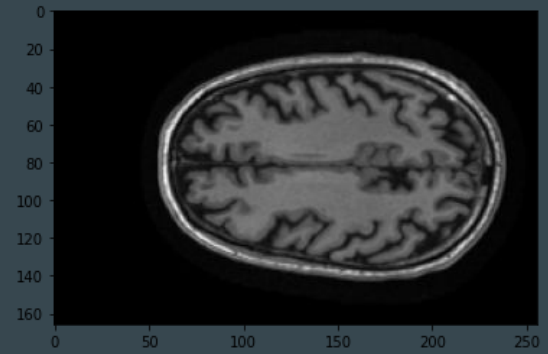
Introduction

- Alzheimer's disease is an irreversible, progressive brain disorder that slowly destroys memory and thinking skills, eventually to ability to carry simple tasks.

- Most people with Alzheimer's, symptoms first appear in their mid 60s.

- Alzheimer's disease is ultimately fatal.



Dementia vs Alzheimer's

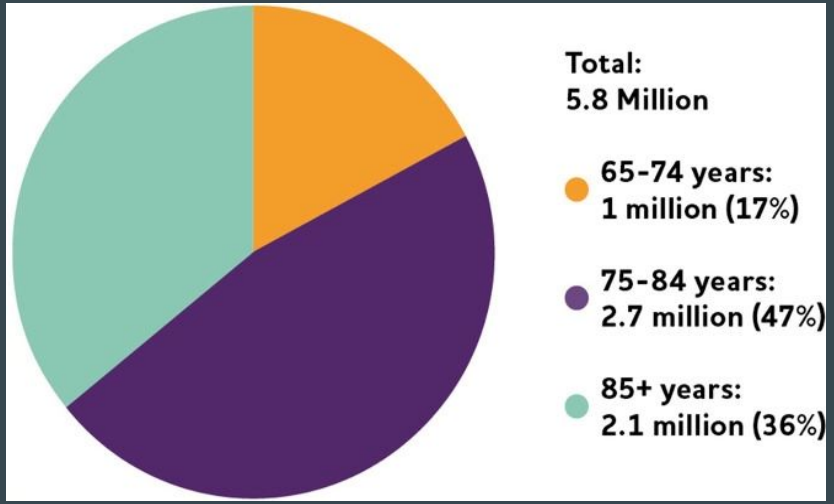
- Dementia is an overall term for a particular group of symptoms like:
- ❖ Difficulty with memory
- ❖ Difficulty with language
- ❖ Difficulty with problem solving and basic thinking skills

- Alzheimer's disease is the most common cause of dementia.

Alzheimer's: Facts and Figures

- An estimated 5.8 million Americans age 65 and older are living with Alzheimer's dementia As of 2020.

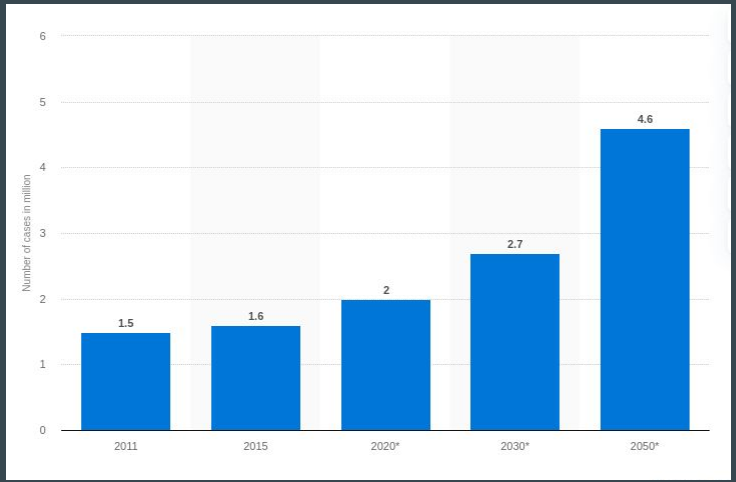
Out of total US population 1 in every 10 person age 65 and older has Alzheimer's.



Created from data from Hebert et al

Alzheimer's: Facts and Figures

- The number of cases of Alzheimer's disease in senior citizen across India in 2050 is forecasted to be 4.6 million.



Published by Statista Research Department

Problems with present system

Medical

- Completely dependent on highly skilled neurologists who are less available.
- Examination requires patient history, long term neuropsychological testing.

Economical

- Paucity of inexpensive clinicians with sufficient Alzheimer's disease diagonstic expertise.
- Long term expensive consultancy process.

Project objective:
To create a deep learning strategy that delineates unique Alzheimer's disease signature from MRI images.

Materials and Methods

Dataset:

Source: ADNI (Alzheimer's Disease Neuroimaging Initiative)

Website: http://adni.loni.usc.edu/

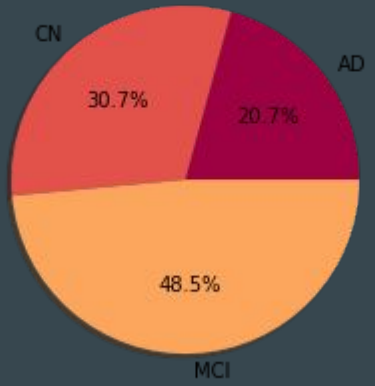
Number of images: 2294 3D MRI images (80 GB approx.)

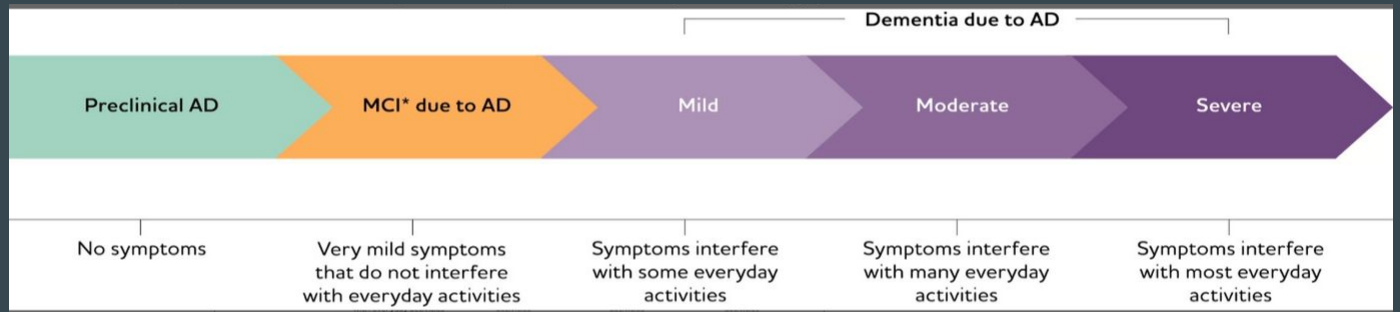
Classes:

- AD (476 images)
- MCI (705 images)
- CN (1113 images)

Exploratory analysis

- **CN(Cognitively Normal):** No signs of depression, mild cognitive impairment, or dementia.
- **MCI(Mild Cognitve Impairment):** Reported to have memory concern but daily life activities are essentially preserved.
- **AD(Alzheimer's Disease):** Characterised by noticeable memory, thinking or behavioral symptoms that impair a person's ability to function.

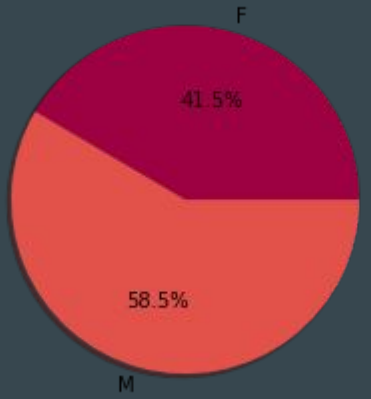




Exploratory analysis

- Number of Male patients: 1341

- Number of Female patients: 953



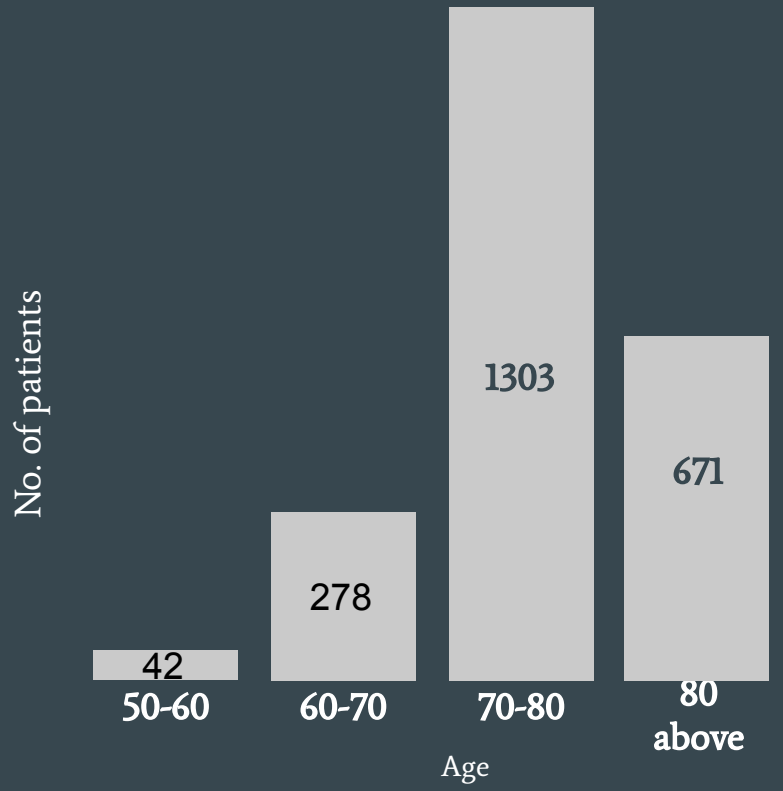
- **Findings:**

The number of male patients is higher than female patients, but not significant enough to conclude that males are more likely to have Alzheimer's than females.

Exploratory analysis

Findings:

The age-bracket vs number of patients graph solidifies the claim that above the age of 60, people are very much prone to Alzheimer's.



Methodology

Preprocessing

- Classifying the unorganised data from the csv file available from the ADNI server.
- Image registration
- Skull stripping
- Creating a 2D MRI image database by slicing the 3D images

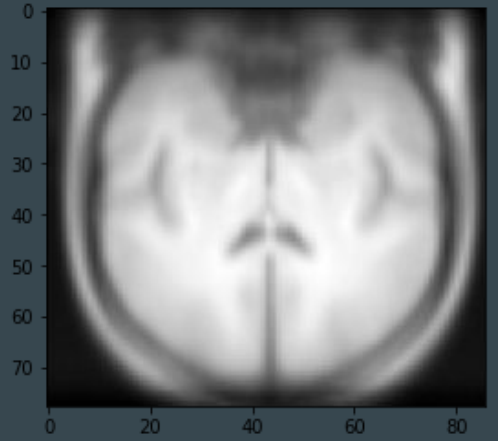
Training

- .tfrecords database built to feed this huge data efficiently to the model
- Train image - 1658
- Validation image -292
- Test image - 344
- Fine-tuning inception-v3 model using the 2D data created
- ResNet3D implemented on the 3D dataset

Preprocessing

Image Registration:

- Image registration consists on adapting a certain image to another reference image.
- spatially normalized to an isotropic resolution of 2mm3
- final resolution of the images is 78x110x86.

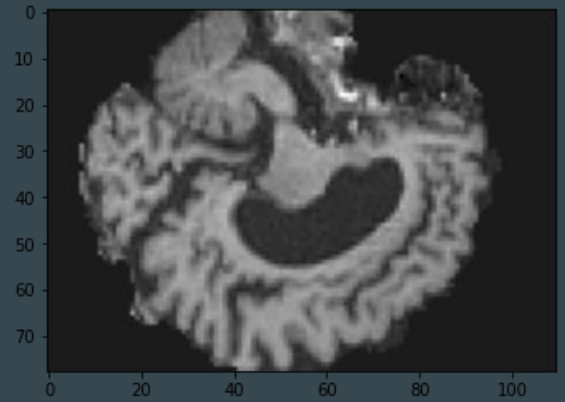


MNI 305 mean atlas

Preprocessing

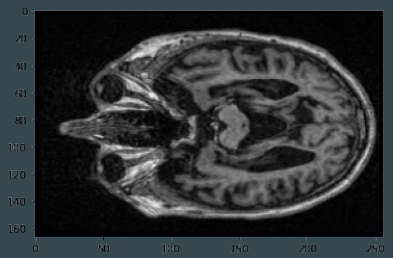
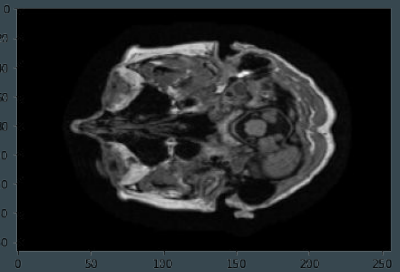
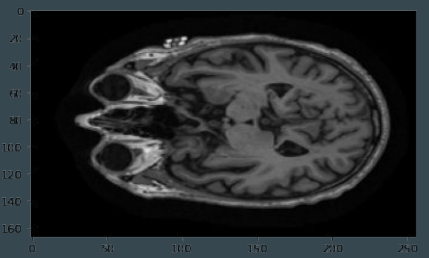
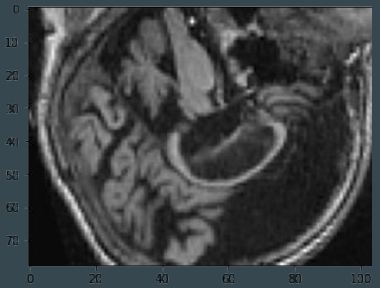
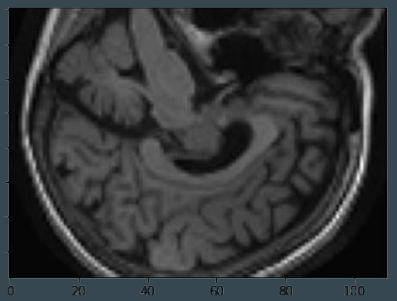
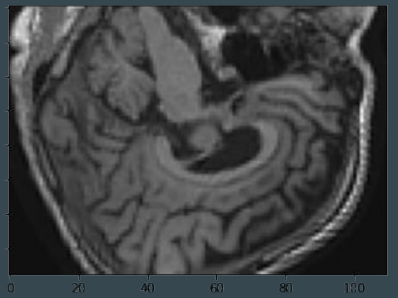
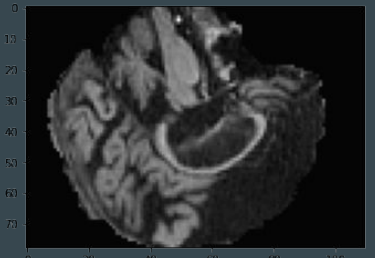
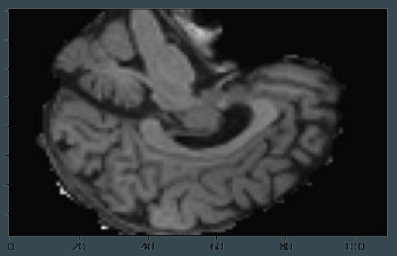
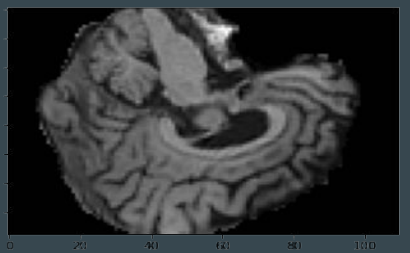
Skull stripping:

- Removing the skull portion as it is irrelevant to the model.
- FSL BET tool implemented by python library Nipype
- Fractional intensity threshold set to 0.3



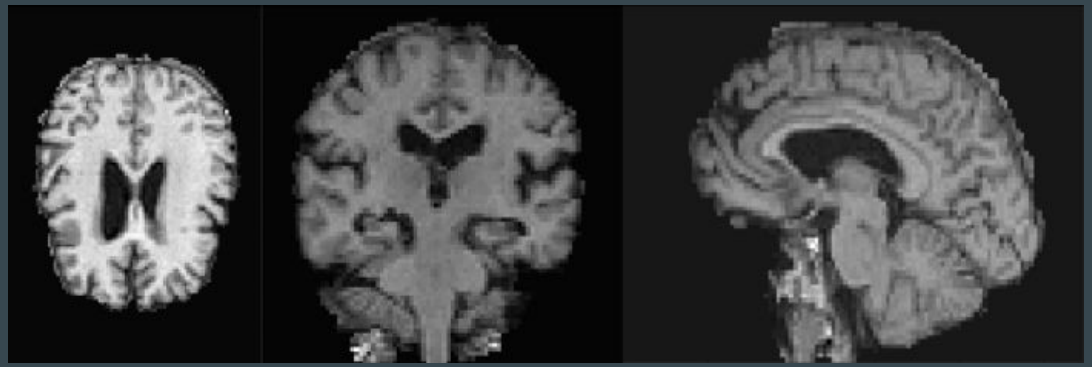
After skull portion is removed

Preprocessing

	AD	MCI	CN
Original			
Registered			
Skull-stripped			

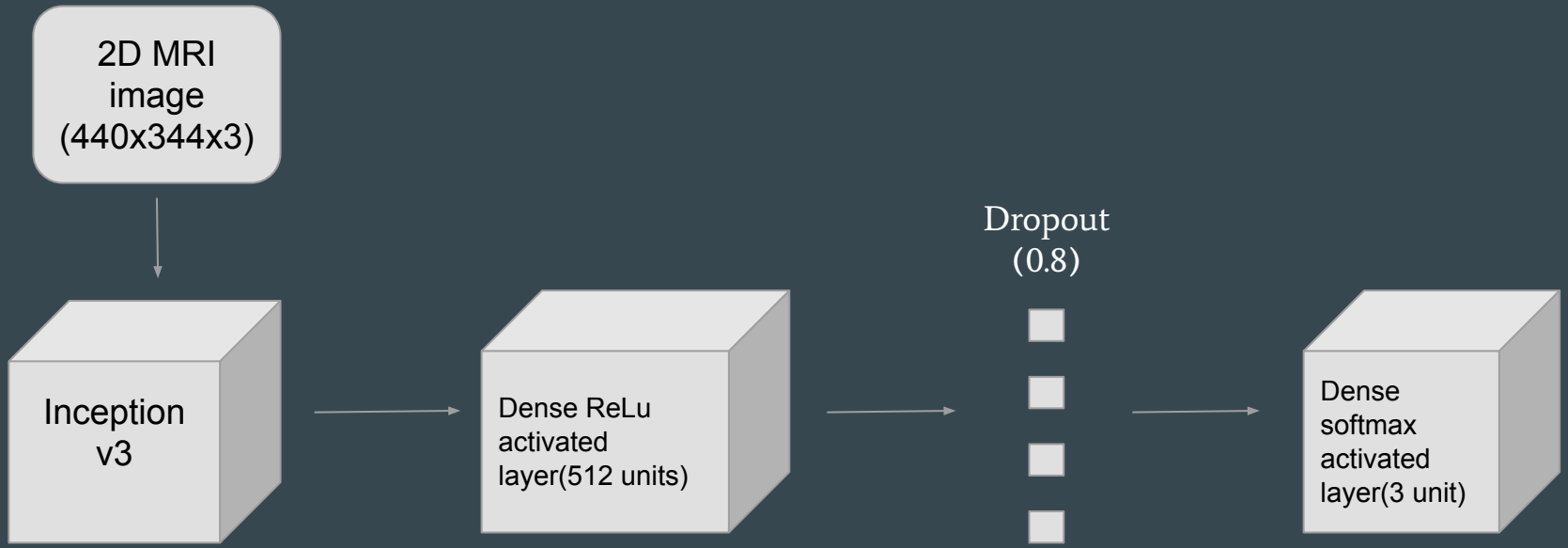
Preprocessing

- A 2D image dataset was created from the resulting 3D dataset.
- Multiple axial(horizontal) cut was made and then placed on the same plane to construct a 2D image.
- Images of dimension 440x344x3
- Whitened for zero mean and one standard deviation.



Axial, coronal and sagittal cuts respectively of a skull-stripped image

Training: Inception v3



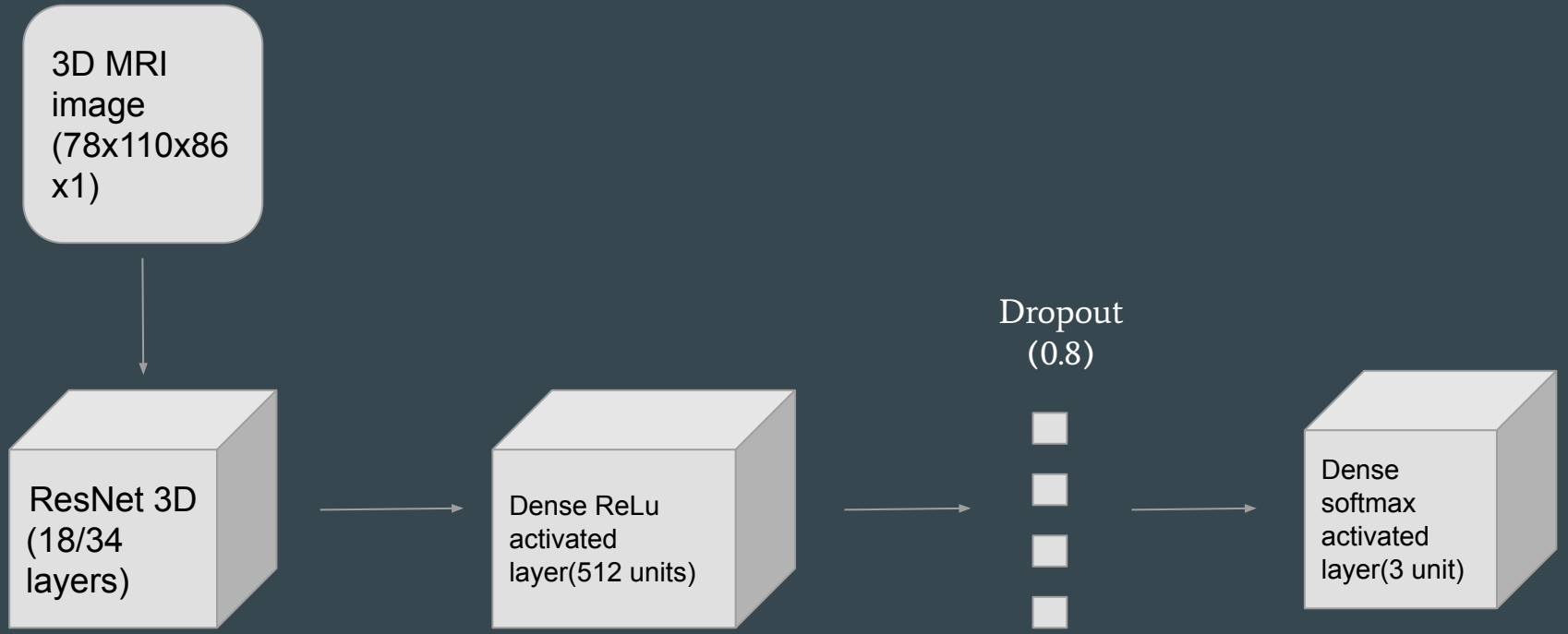
Training: inception v3

```
optimizer = tf.keras.optimizers.Adam(lr=0.0001, decay=1e-3)
model.compile(optimizer=optimizer, loss='categorical_crossentropy',
              metrics=['acc'])
```

```
optimizer = tf.keras.optimizers.Adam(lr=0.0001, decay=1e-6)
model.compile(optimizer=optimizer, loss='categorical_crossentropy',
              metrics=['acc'])
```

$$\text{Loss} = -\sum_{i=1}^{\text{output size}} y_i \cdot \log \hat{y}_i$$

Training: ResNet 3D



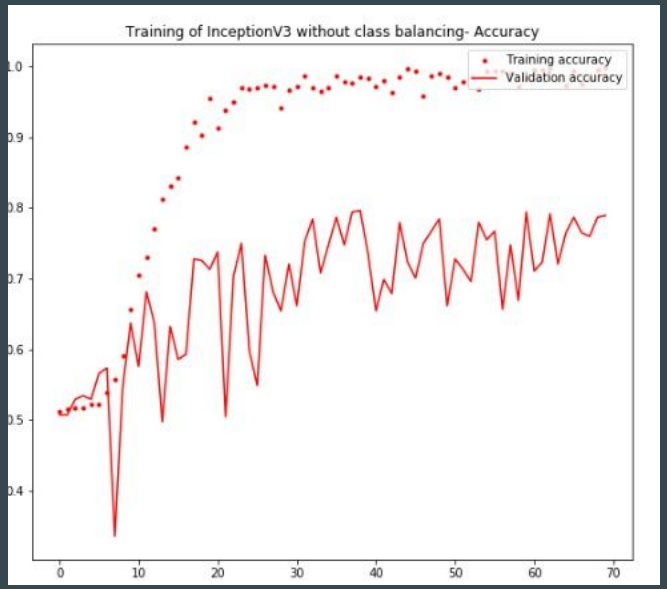
Training: ResNet 3D

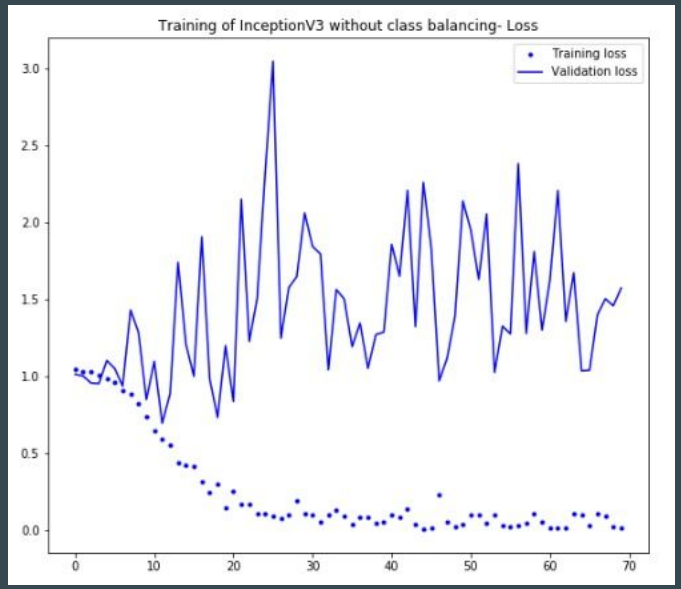
```
base_model = Resnet3DBuilder.build_resnet_34(
    input_shape=IMG_SHAPE,
    num_outputs=N_CLASSES,
    reg_factor=0.01
)

fc_layer = tf.keras.layers.Dense(512, activation='relu')(base_model.layers[-2].output)
fc_layer = tf.keras.layers.Dropout(0.8)(fc_layer)
output_layer = tf.keras.layers.Dense(N_CLASSES, activation='softmax')(fc_layer)
model = tf.keras.models.Model(inputs=base_model.input, outputs=output_layer)
```

```
optimizer = tf.keras.optimizers.Adam(lr=0.001)
model.compile(optimizer=optimizer,
              loss='categorical_crossentropy',
              metrics=['acc'])
```

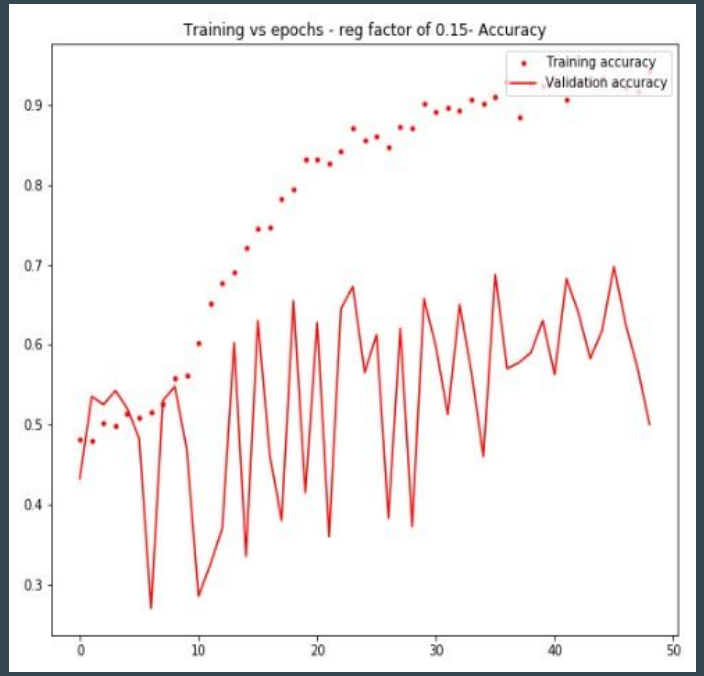
$$\text{Loss} = -\sum_{i=1}^{\substack{\text{output}\\ \text{size}}} y_i \cdot \log \hat{y}_i$$

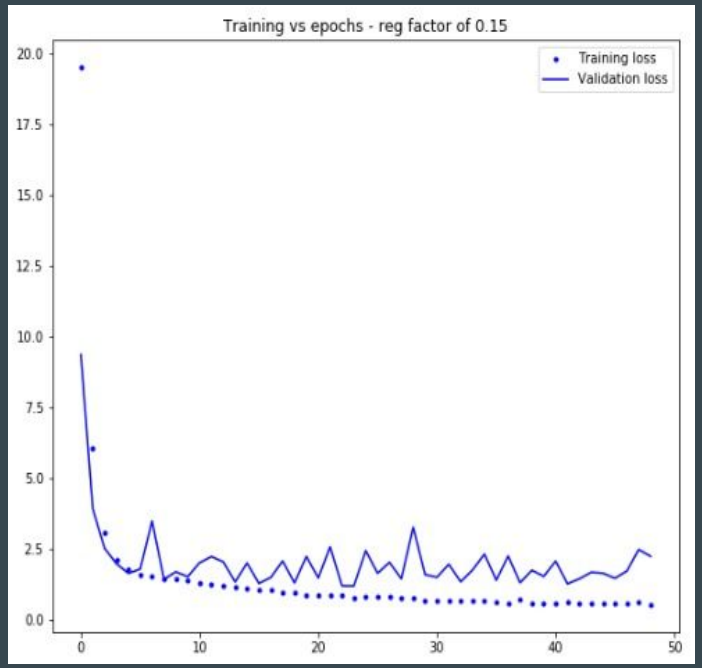
Results: inception v3





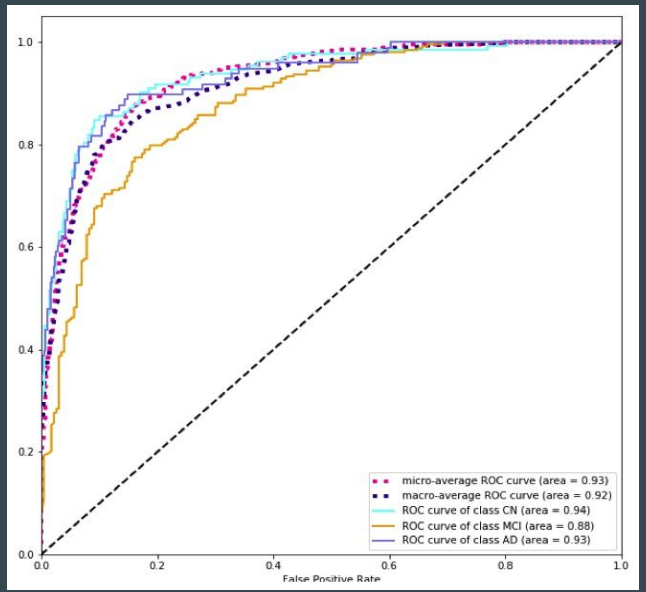
Results: ResNet 3D



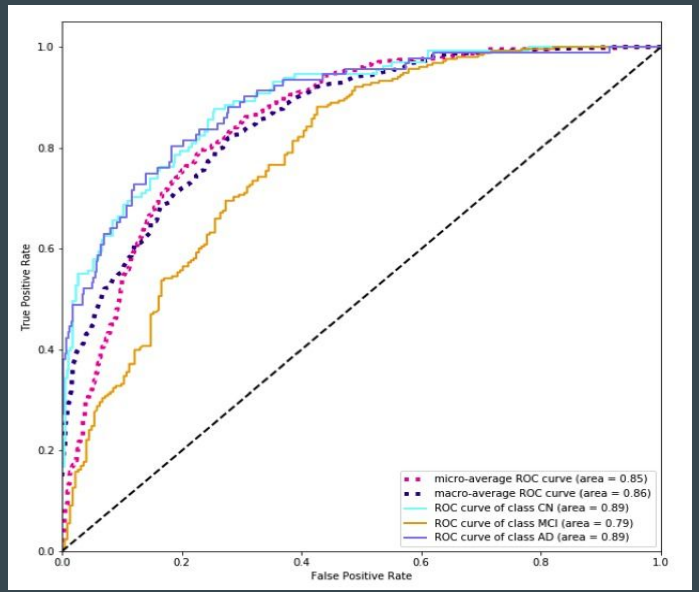


Test Results

True positive rate



Results from inception v3 model



Results from ResNet3D model

THANK YOU