Alzheimer's Disease Detection using Deep Learning

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AIM

The aim of this research project is to successfully classify the images of **ADNI** dataset into **five** classes of **Alzheimer's Disease** namely:

1. Alzheimer's Disease
2. Mild Cognitive Impairment
3. Late Mild Cognitive Impairment
4. Early Mild Cognitive Impairment
5. Control Normal

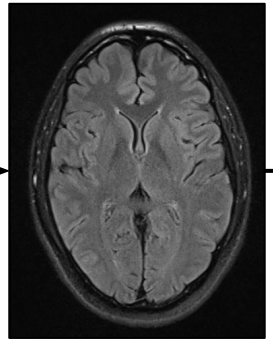
INTRODUCTION

Alzheimer's disease (AD) is a prominent cause of death in developed countries. Although significant findings have been reported utilizing computer-aided algorithms in research, no practically applicable diagnostic approach is available. Deep models have grown in popularity in recent years, particularly when dealing with images. Deep learning has gained significant attention in AD detection research since 2017. Deep models have been shown to be more accurate than typical machine learning techniques in detecting Alzheimer's disease which give promising results with successful implementation in clinical settings that necessitate a mix of high accuracy, fast processing time, and generalizability to varied populations. Although deep learning has shown promising results in diagnosing Alzheimer’s disease, there are significant constraints, particularly in terms of dataset availability and training process.

Next slide shows the basic process for Alzheimer’s Disease Detection.

INTRODUCTION

Imaging Equipment



Dataset

Brain Image

Image Segmentation

Segmented Image

Feature Extraction

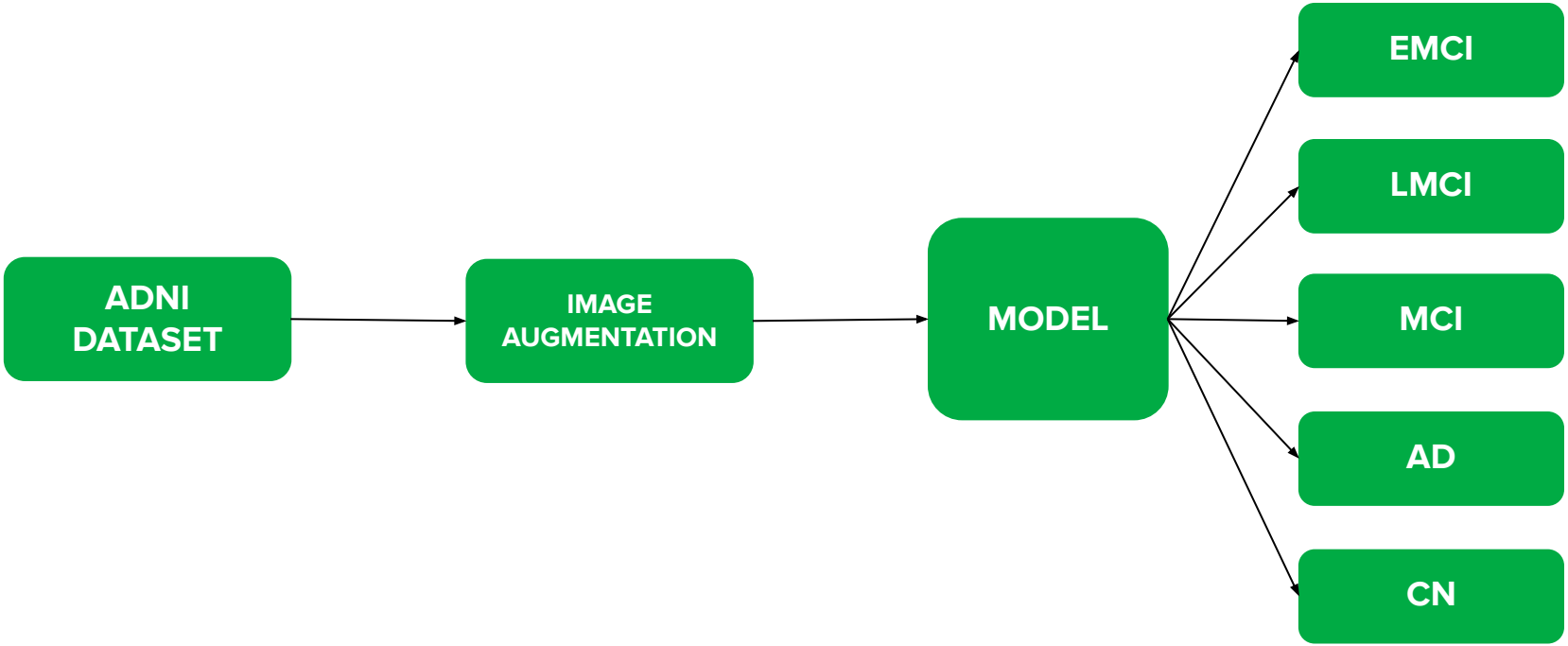
Extracted Features

Image recognition with AI technique

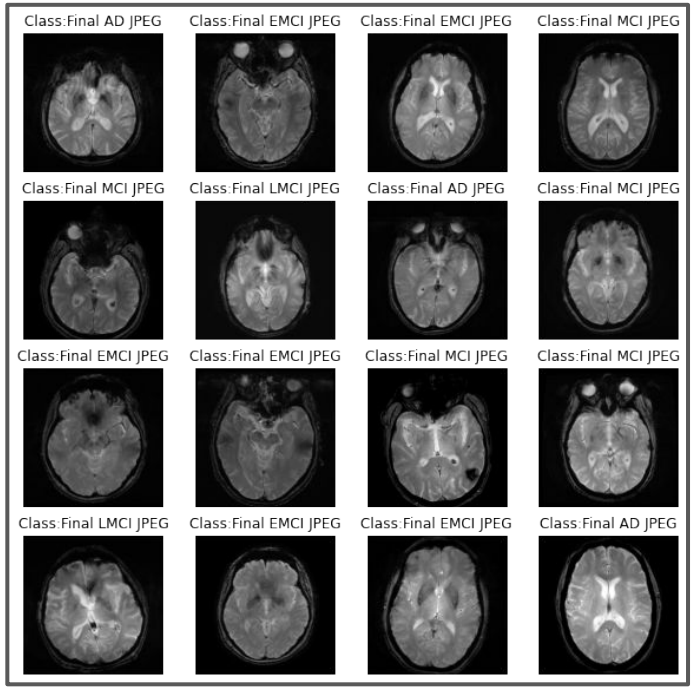
Recognised Image

Alzheimer's Disease Detection

INTRODUCTION



DATASET

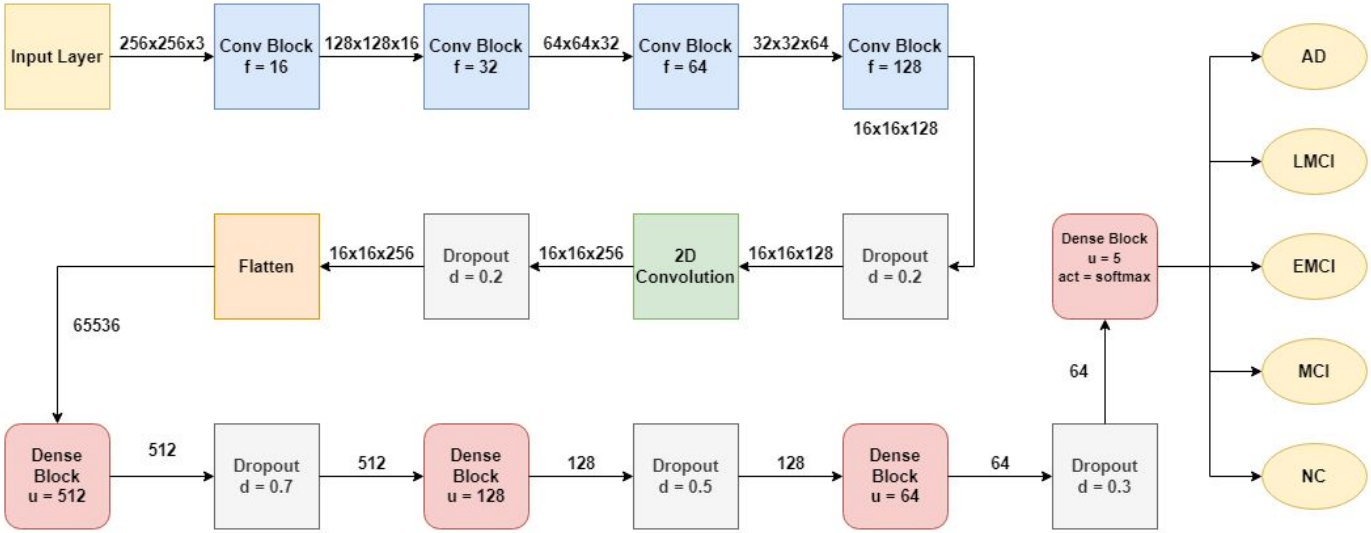


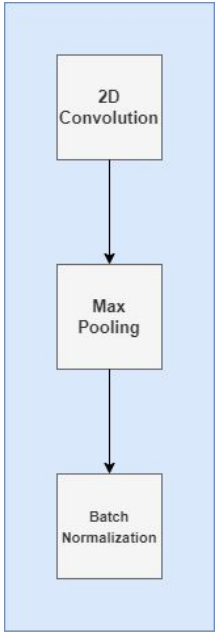
The dataset to be used is Alzheimer's Disease Neuroimaging Initiative (ADNI).

We are majorly classifying into 5 classes:

1. **AD (Alzheimer's Disease)**
2. **MCI (Mild Cognitive Impairment)**
3. **LMCI (Late Mild Cognitive Impairment)**
4. **EMCI (Early Mild Cognitive Impairment)**
5. **CN (Control Normal)**

BLOCK DIAGRAM





Conv Block

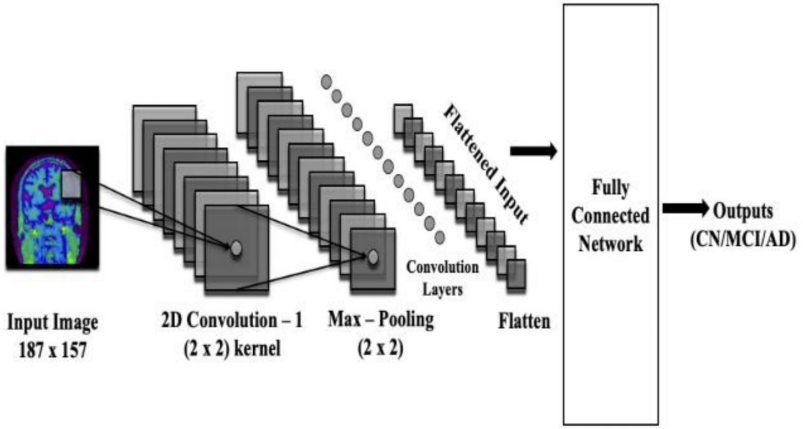
PROJECT STAGES

STAGE 1: Paper Review

- Hosseini-Asl, Ehsan, Robert Keynton, and Ayman El-Baz. "**Alzheimer's disease diagnostics by adaptation of 3D convolutional network**." *2016 IEEE international conference on image processing (ICIP)*. IEEE, 2016.
- Islam, Jyoti, and Yanqing Zhang. "**A novel deep learning based multi-class classification method for Alzheimer's disease detection using brain MRI data**." *International conference on brain informatics*. Springer, Cham, 2017.
- Korolev, Sergey, et al. "**Residual and plain convolutional neural networks for 3D brain MRI classification**." *2017 IEEE 14th international symposium on biomedical imaging (ISBI 2017)*. IEEE, 2017
- Liu, Siqi, et al. "**Early diagnosis of Alzheimer's disease with deep learning**." *2014 IEEE 11th international symposium on biomedical imaging (ISBI)*. IEEE, 2014.
- Pradhan, Amnaya, Jerin Gige, and M. Eliazer. "**Detection of Alzheimer's disease (AD) in MRI images using deep learning**." *Int. J. Eng. Res. Technol.(IJERT)* 10 (2021): 580-585.
- Ji, Huanhuan, et al. "**Early diagnosis of Alzheimer's disease using deep learning**." *Proceedings of the 2nd International Conference on Control and Computer Vision*. 2019.
- Shahina, A., and Nayeemulla Khan. "**Detection of Alzheimer's Disease on Brain MRI using Inception V3 Network**."

STAGE 1: Paper Review

The Paper **"Detection of Alzheimer's Disease on Brain MRI using Inception V3 Network."** by Shanmuga Skandh Vinayak E, Shahina A and Nayeemulla Khan A which classified the data into **3** classes of Alzheimer's Diseases **(CN, MCI, AD)** was considered as a base paper for our project which gave **82.89%** accurate results**.**



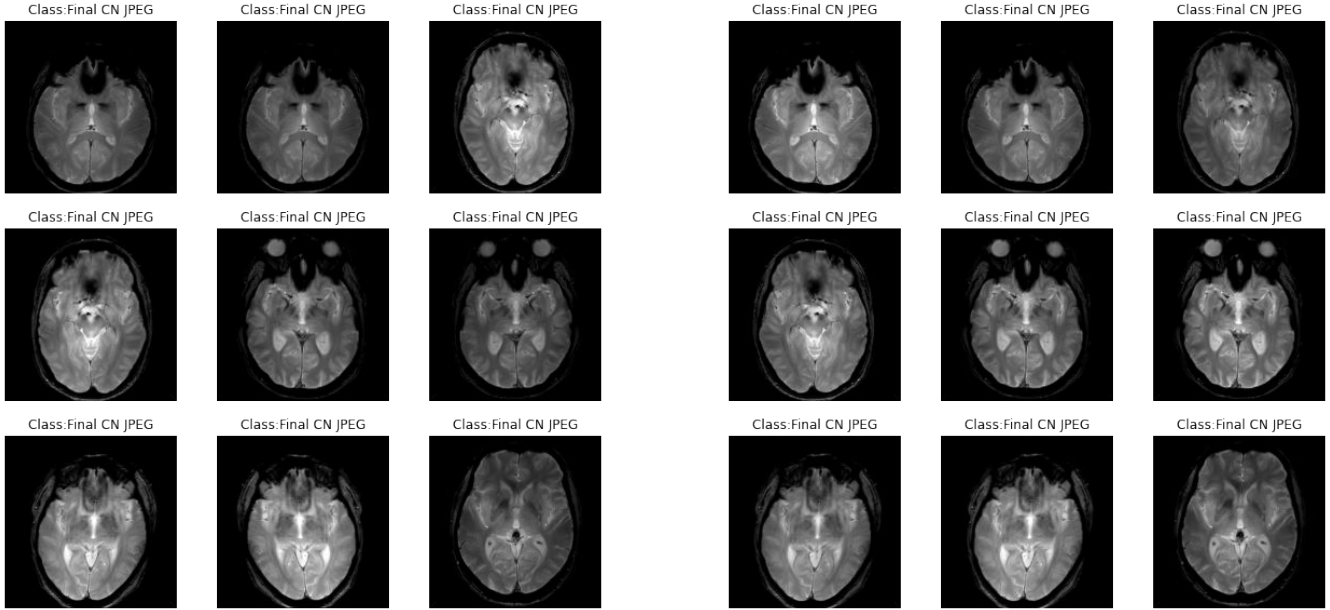
Architecture used in the base paper

STAGE 2: Base Model Performance

- Created a model based on the architecture given in the base paper.
- Converted the model from a **three** class classifier to a **five** class classifier.
- Trained the model on the ADNI dataset.
- Results:
  - Training Accuracy: 83.78%
  - Validation Accuracy: 62.07%
  - Testing Accuracy: 61.90%

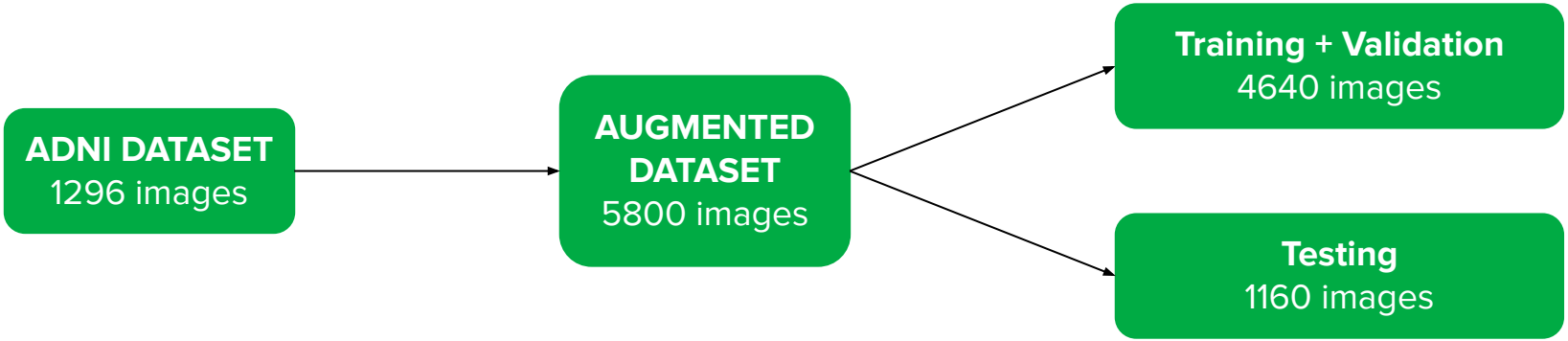
STAGE 3: Dataset

- Applied Image Augmentation on the ADNI Dataset from 1296 images originally to 5800 images.



STAGE 3: Dataset

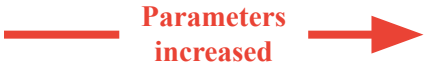
- Splitting the augmented dataset into:
  - Training + Validation : 80%
  - Testing : 20%



STAGE 4: Improvisation

- Constructed a custom CNN model which increased the parameters from 9,644,501 parameters to 34,022,757 parameters.

```
Total params: 9,646,869
Trainable params: 9,644,501
Non-trainable params: 2,368
```




```
Total params: 34,022,757
Trainable params: 34,022,277
Non-trainable params: 480
```

STAGE 5: Applying K-Fold

- Applied K-Fold (with k=5, 10, 20) on our proposed CNN model.
- Epochs = 100
- Batch Size = 32

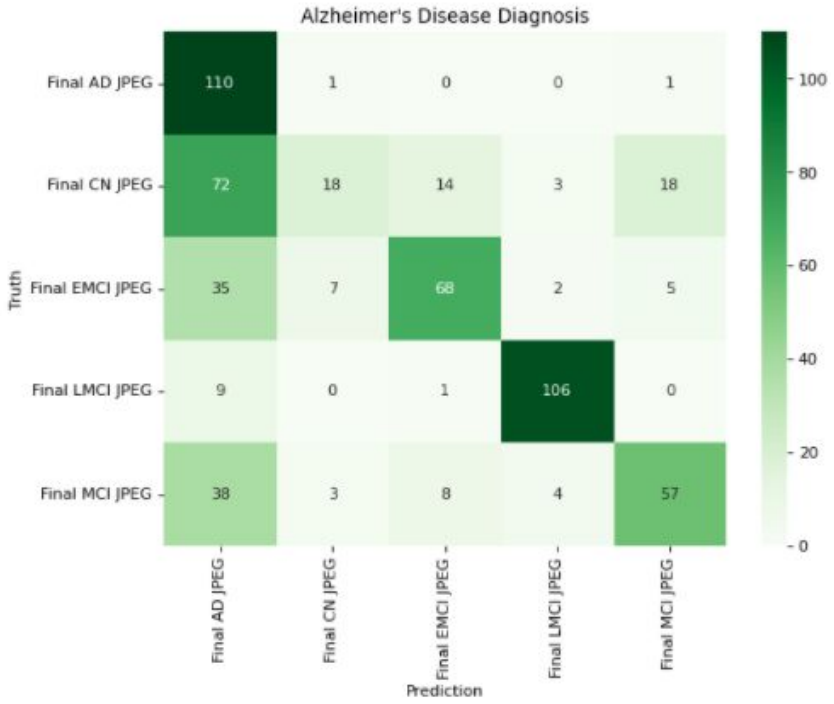
K - value	Train : Val	Training	Validation
K = 5	4 : 1	3712	928
K = 10	9 : 1	4176	464
K = 20	19 : 1	4408	232

PRELIMINARY RESULTS

Training Accuracy: 83.78%

Validation Accuracy: 62.07%

Testing Accuracy: 61.90%

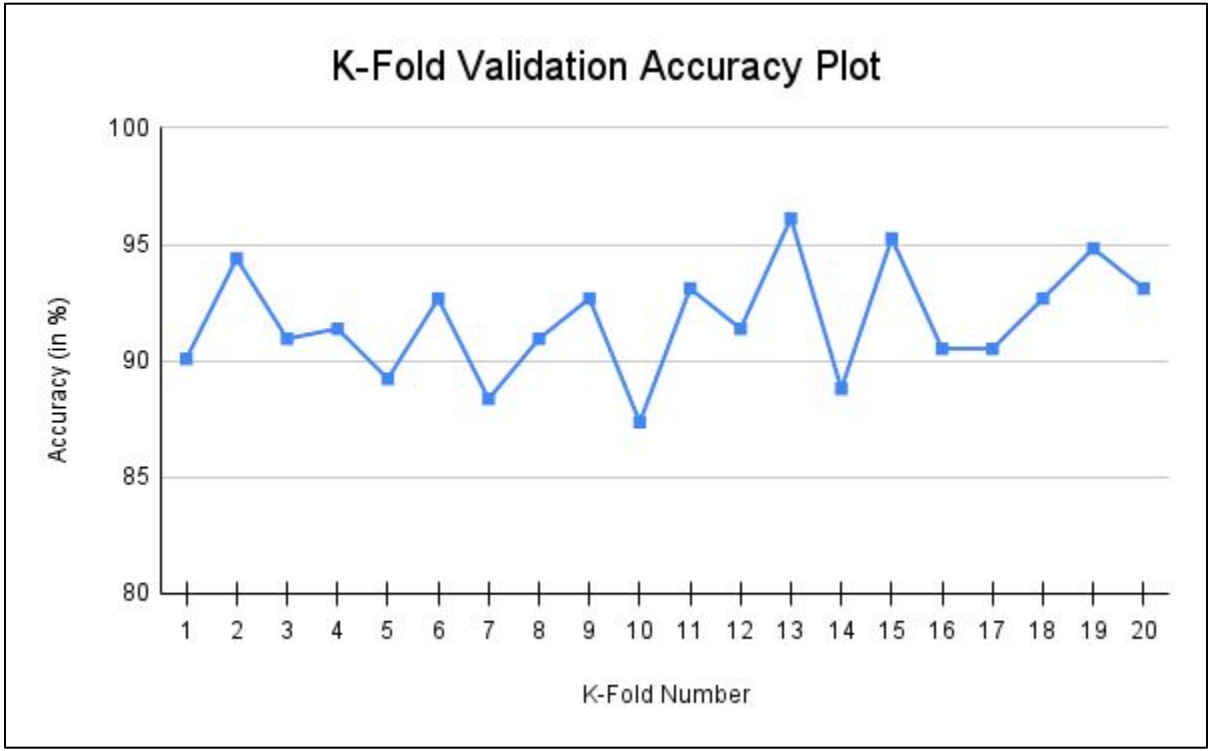


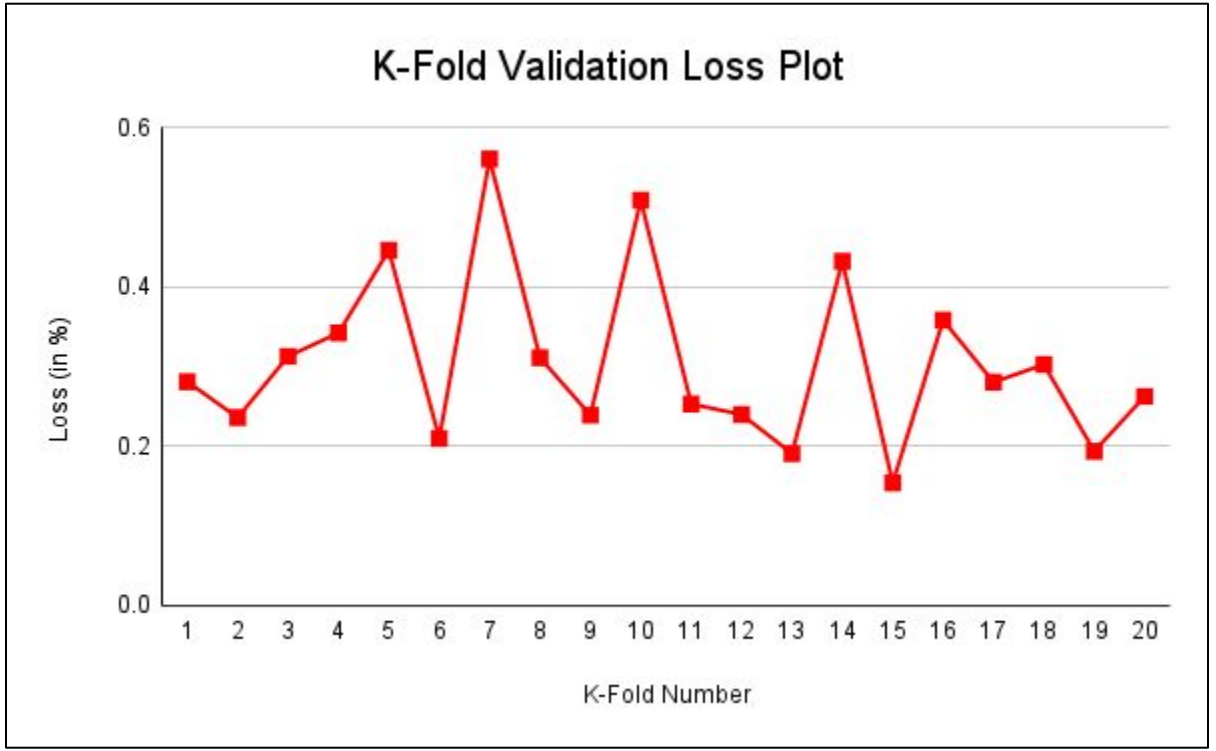
ACHIEVED RESULTS

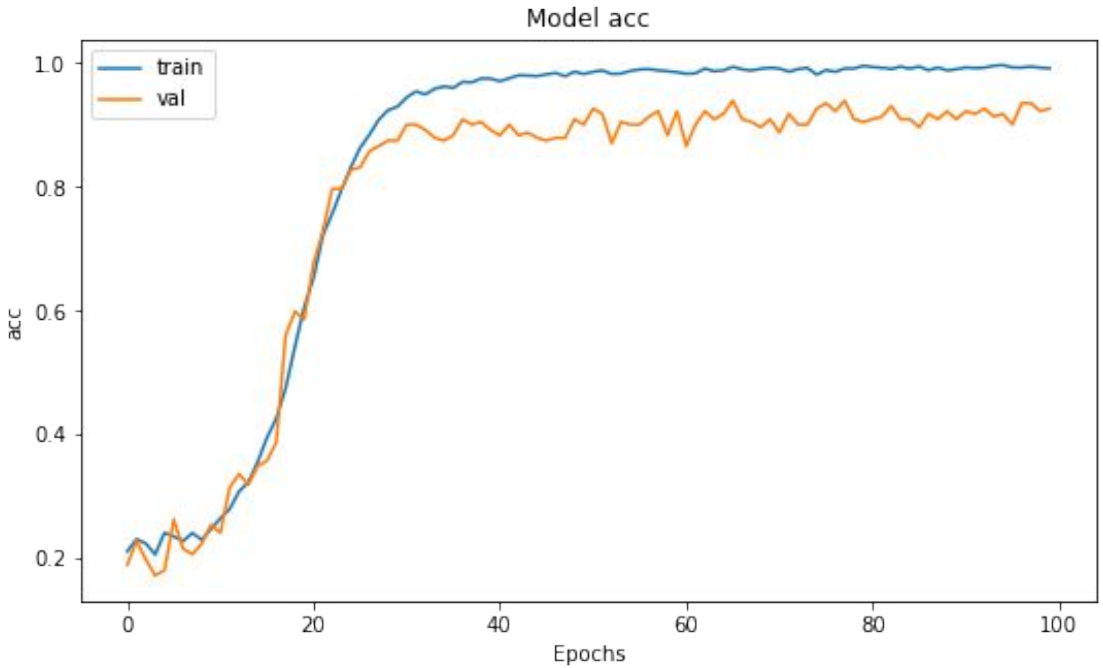
S. No.	Validation Accuracy (in %)
1	90.08620381
2	94.39654946
3	90.94827771
4	91.3793087
5	89.22413588
6	92.67241359
7	88.36206794
8	90.94827771
9	92.67241359
10	87.36793785

S. No.	Validation Accuracy (in %)
11	93.10345054
12	91.3793087
13	**96.1206913**
14	88.79310489
15	95.2586174
16	90.51724076
17	90.51724076
18	92.67241359
19	94.82758641
20	93.10345054

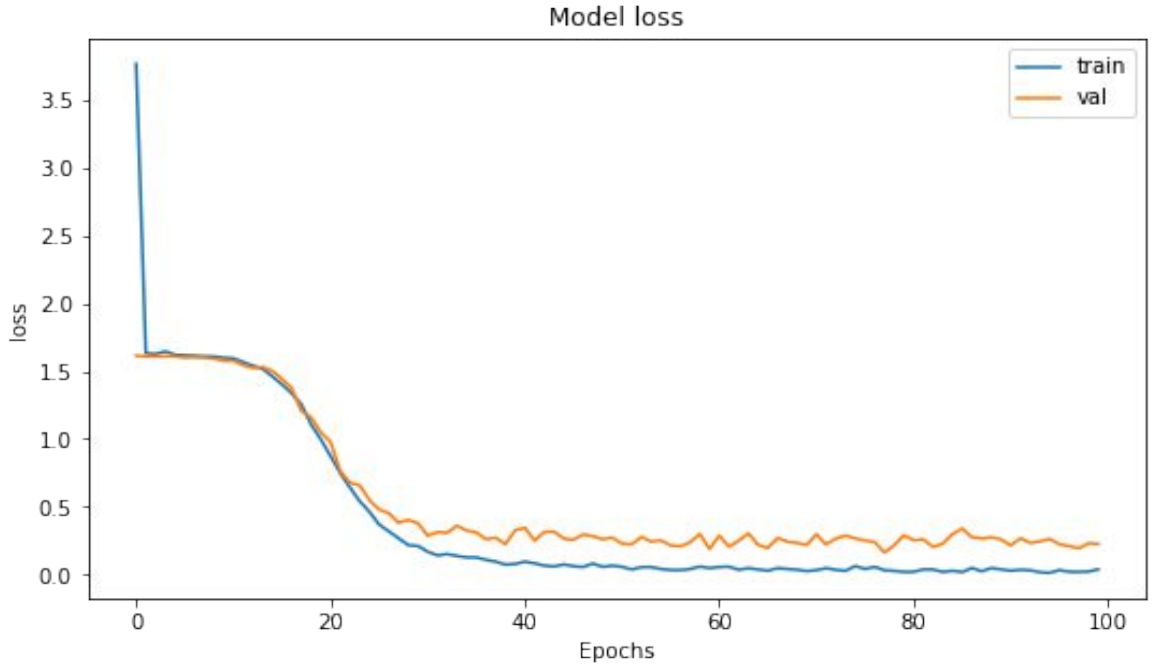
Average Validation Accuracy
91.71753456%


K-Fold Validation Accuracy Plot
Accuracy (in %)
100
95
90
85
80
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
K-Fold Number


K-Fold Validation Loss Plot
Loss (in %)
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
K-Fold Number



Accuracy Graph for model 13



Loss Graph for model 13

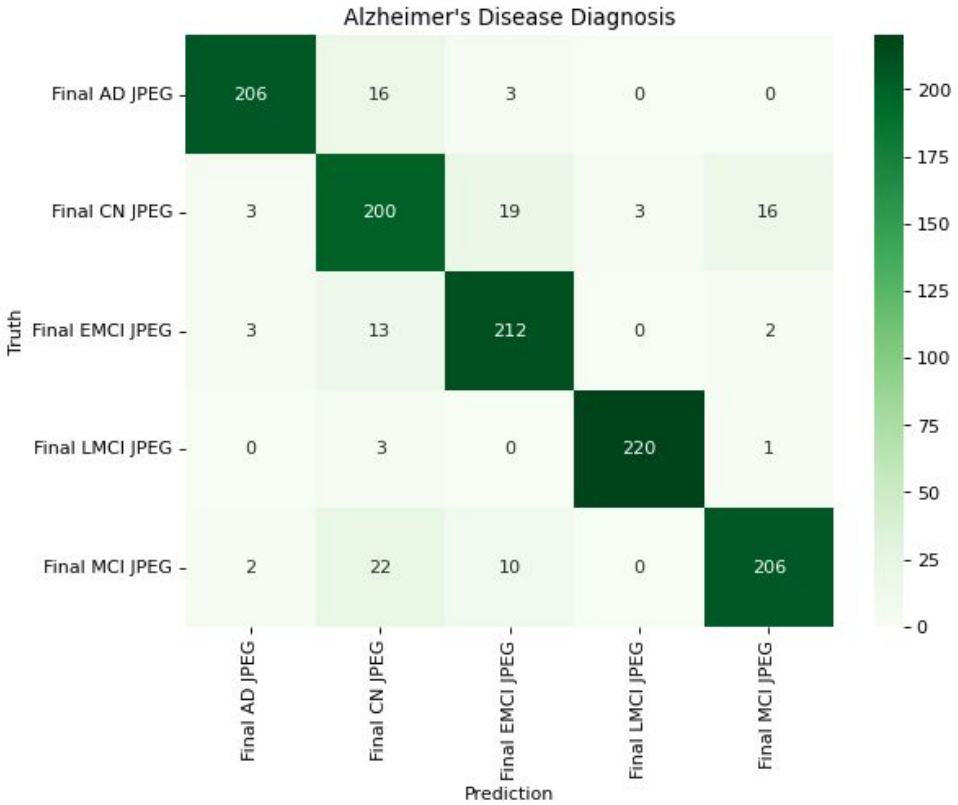
Classification Report of Model 13

	precision	recall	f1-score
Final AD JPEG	0.96	0.92	0.94
Final CN JPEG	0.79	0.83	0.81
Final EMCI JPEG	0.87	0.92	0.89
Final LMCI JPEG	0.99	0.98	0.98
Final MCI JPEG	0.92	0.86	0.89

Evaluation of Model 13

Validation Accuracy: 91.27%

Testing Accuracy: 90.00%



NEXT STEPS

- Currently writing research paper on our project and aiming for publication mostly in the following journals:
  - **Journal of Medical Artificial Intelligence,** https://jmai.amegroups.com/
  - **Involvement of Machine Learning Tools in Healthcare Decision Making,** https://www.hindawi.com/journals/jhe/2021/6679512/
  - **Machine Learning in Health and Biomedicine,** https://collections.plos.org/collection/mlforhealth/

REFERENCE LINKS

1. *https://arxiv.org/abs/1607.00455*
2. *https://link.springer.com/chapter/10.1007/978-3-319-70772-3_20*
3. *https://arxiv.org/abs/1701.06643*
4. *https://ieeexplore.ieee.org/document/6868045*
5. *https://www.ijert.org/detection-of-alzheimers-disease-ad-in-mri-images-using-deep-learning*
6. https://dl.acm.org/doi/abs/10.1145/3341016.3341024

THANK YOU