Onion Crop Disease Detection & Classification using CNNs

BTP II
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Outline

- Motivation
- Dataset
- Model
- Results & Experiments
- Conclusion

Motivation

- India is the second largest onion-growing country globally, accounting for approximately 20% of the global onion production
- Aim to investigate the performance of different CNN models for onion crop classification and to identify the most accurate model
- Deep learning has shown great potential for crop disease detection, and further research in this area could significantly improve food security and sustainability

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Onion Dataset

- Anthracnose disease : 20 images
- Basal rot : 111 images
- Bulb rot seed : 304 images
- Damping off : 187 images
- Healthy : 101 images
- Iris yellow spot virus : 5 images
- Purple blotch disease : 9 images
- Stemphylium blight disease : 48 images

Total 8 classes of onion images in the data

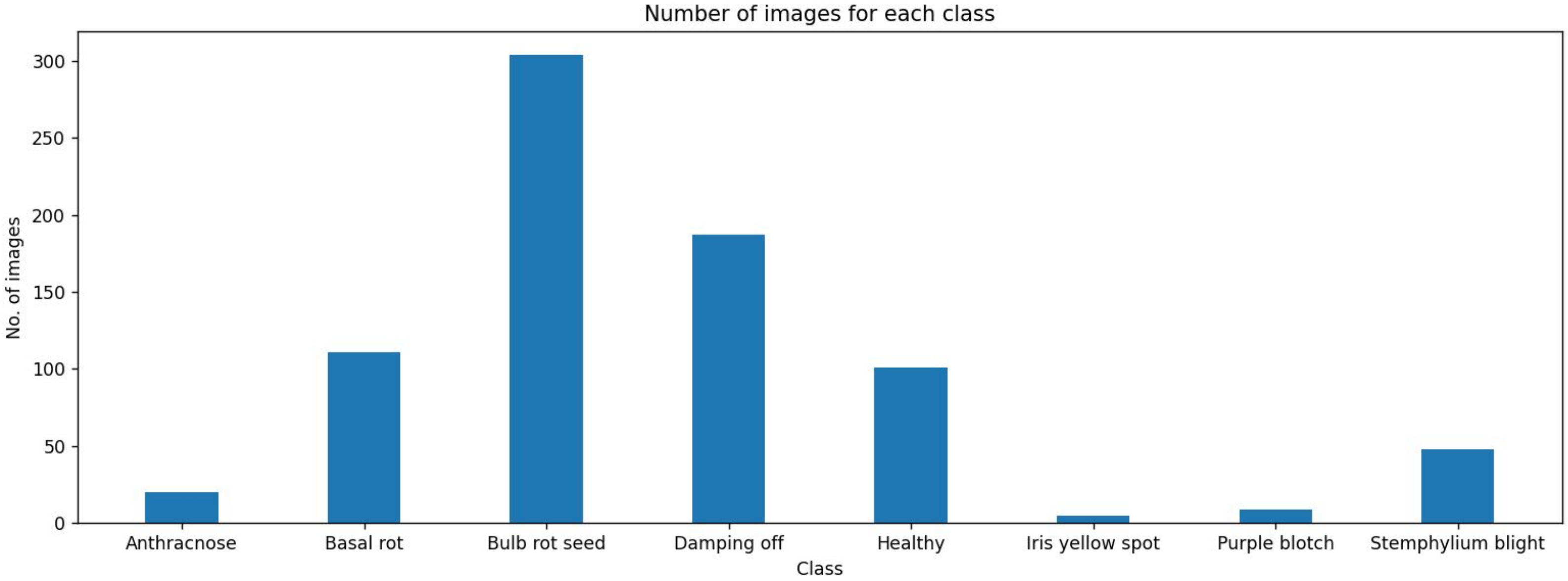

Figure 1: Diseases Split in Onion Dataset

Dataset Images

Stemphylium blight

Healthy

Damping off

Bulb rot

Anthracnose

Iris yellow spot

Figure 2: Onion Dataset

Plant Village Dataset

- 256 x 256 size images
- 38 Plant leaf classes & 1 background image class
- 54000 total images

Corn Northern Leaf Blight

Grape Leaf blight

Peach Bacterial_spot

Figure 3: Plant Village Dataset

Source : (https://data.mendeley.com/datasets/tywbtsjrjv/1)

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Model Training for Binary Classification

- Pre-trained Baseline models trained as feature extractors or fine tuned on the **Plant Village Dataset**
- The final linear layer of the baseline models is replaced with a **Linear Block** which outputs 39 values corresponding to each class in Plant Village
- Replacing the 39 node linear layer with 2 node layer for Healthy and Diseased onion classification

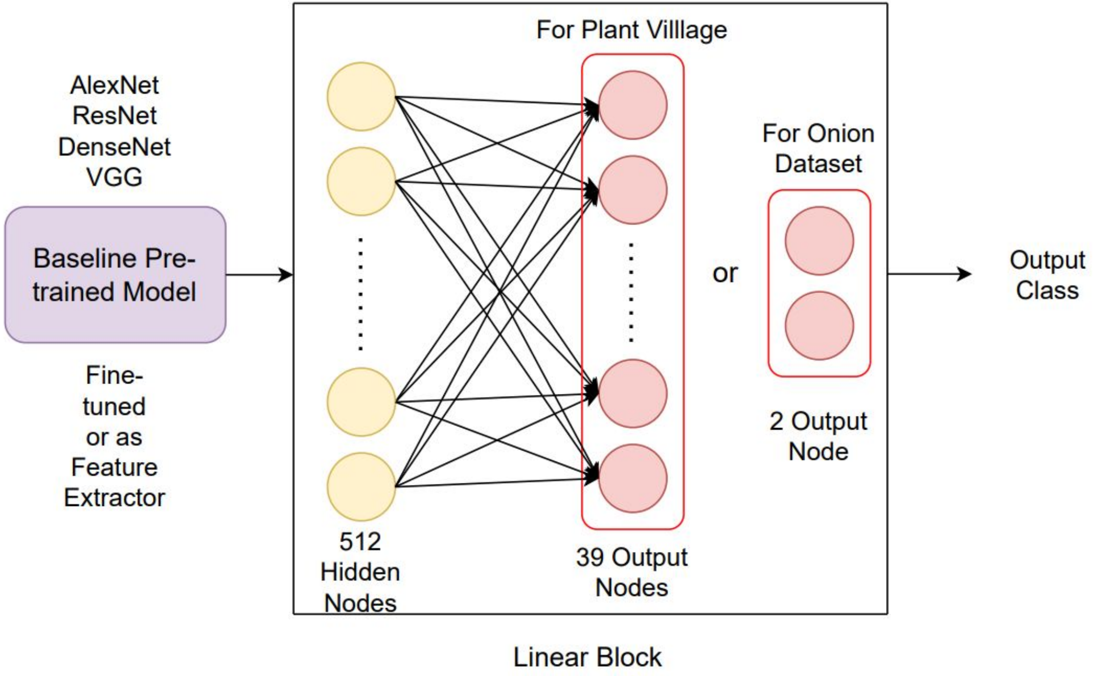

Figure 4: Model

Train and Test Set of Onion Images

The number of diseased class images in the dataset are significantly larger than that of the healthy class as seen in Figure 4.
The onion images are split into a training (70%) and test split (30%) as shown in Figure 5.

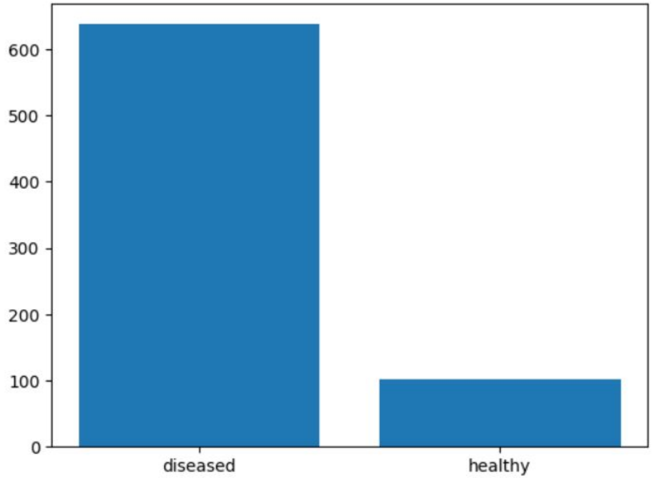

Fig 5: Number of Diseased and Healthy images

	Train	Test	Total
Healthy	72	30	102
Diseased	449	195	644

Table 1: Number of images

Imbalance Dataset Sampler

Sampling different classes differently during training to keep the number of images seen during training for each class similar

- Under-sampling the majority class
- Over-sampling the minority class

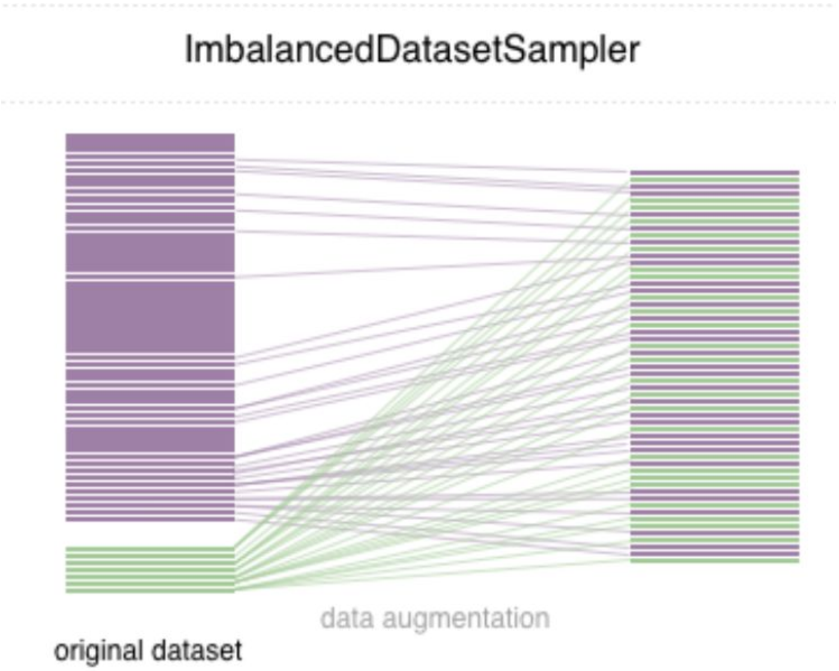

Fig 6: Imbalance Dataset Sampler

CutMix Data Augmentation

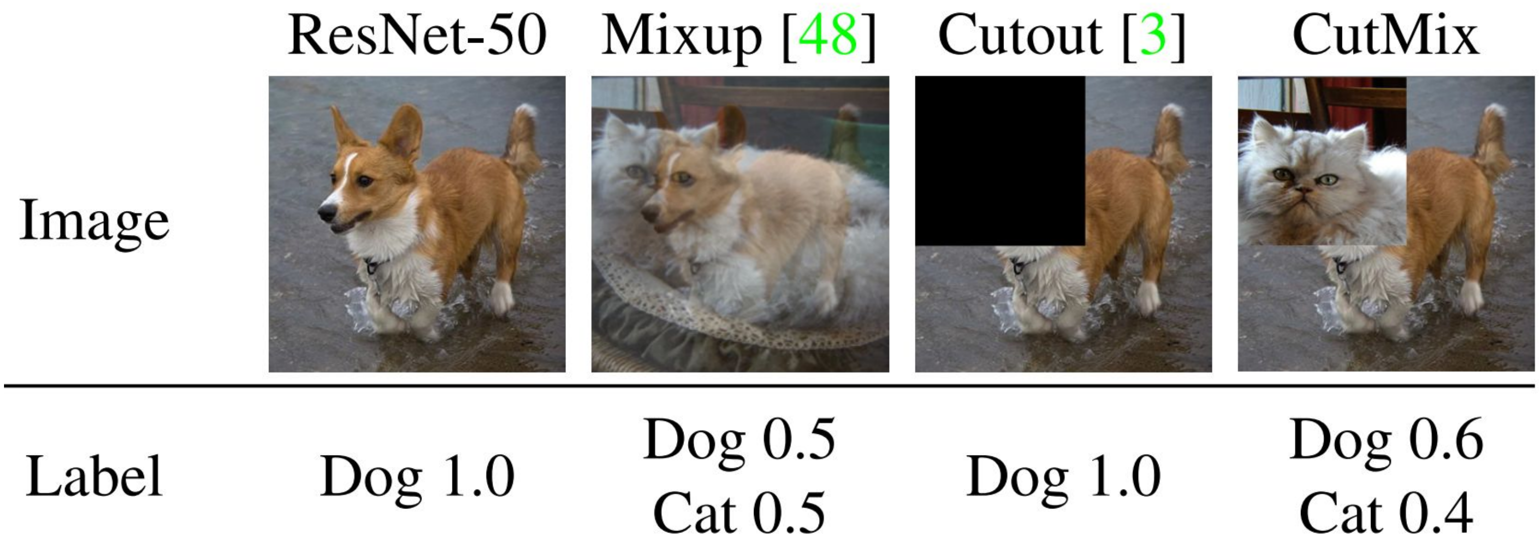

Fig 7: Different Data Augmentations

CutMix augmentation, replaces a patch in the original image with a patch from another image in the training dataset. The label is modified accordingly. This helps in building a more robust model

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Parameters

Plant Village Pre-training

- Batch Size = 32
- Loss function : Negative Log Likelihood Loss
- Optimizer : Adam
  - Learning Rate
    - For Feature Extracting = 0.01
    - For Fine tuning = 0.0001
  - Decay LR by 0.1 factor every 5 epochs

Onion Disease Detection & Classification

- Batch Size = 16
- Loss Function = Negative Log Likelihood Loss
- Optimizer : Adam
  - Learning Rate = 0.001
  - Decay LR by 0.1 factor every 3 epochs

CutMix Parameters

- Probability of CutMix = 0.5
- Alpha = 0.8

Baseline Models Trained on Plant Village

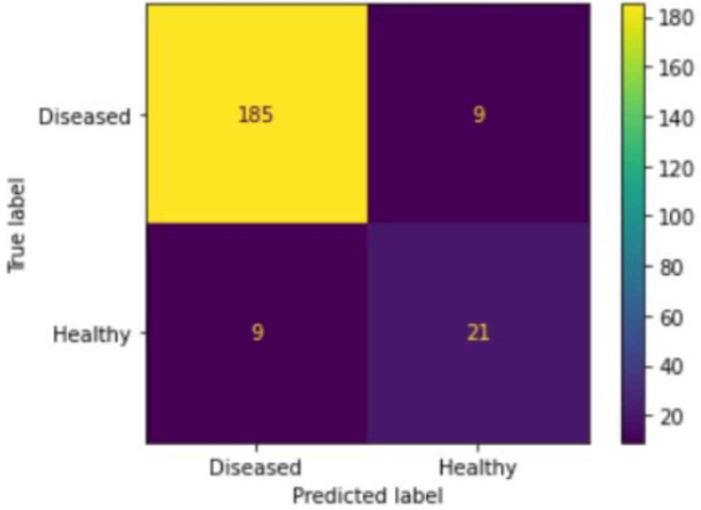
Table 2: Results with Plant Village

Model Name	No. of Trainable Parameters	Accuracy on Plant Village (%)		Model Size (in MB)
		Feature Extract	Fine-tuning (every 20 batch)	
AlexNet	62.3 million	92.3	96.4	225
VGG11	133 million	91.45	97.25	500
DenseNet121	8 million	96.1	97.8	29
ResNet18	11 million	94.8	97.2	44
ResNet50	23 million	95	98.1	94
ResNet152	60 million	96.1	98.5	226
Inception Net	25 million	-	96.3	98

Binary Classification Results with Onion Dataset

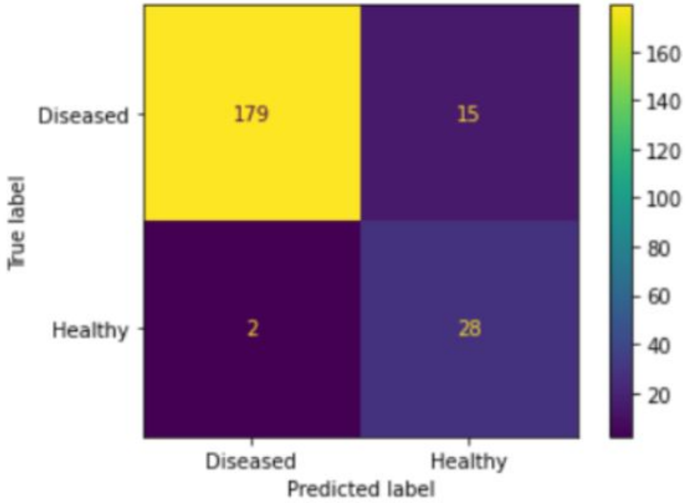
1. Densenet with CutMix

Accuracy = 0.9196
Precision = 0.9536
Recall = 0.9536
F Score = 0.9536



DenseNet without CutMix

Accuracy = 0.924
Precision = 0.9889
Recall = 0.922
F Score = 0.9547



Binary Classification Results with Onion Dataset Contd.

Model	**Accuracy %**	**F-Score**
DenseNet	**92.4**	**0.9547**
ResNet50	90	0.945
AlexNet	91.5	0.949
VGG11	90	0.9448
InceptionNet	83	0.89

Accuracy & F-Score of different baseline models

GradCam Observations

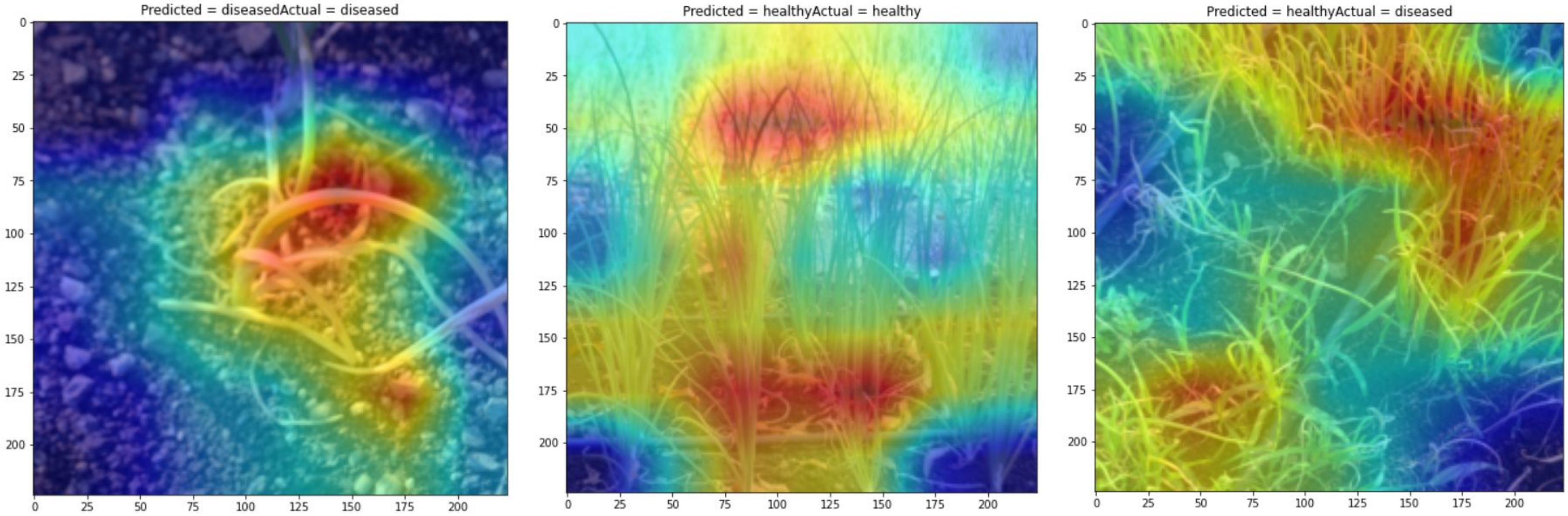


Fig 8: GradCam Heatmaps

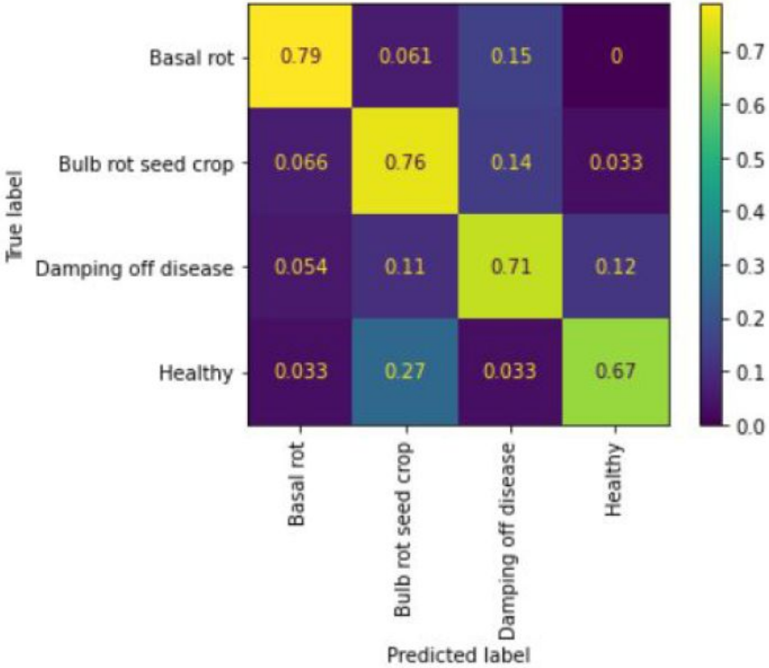
- Specifies the areas of the image which led to the predictions seen
- The GradCam heatmaps shows that the model is able to look at the crop part of the image selectively, and ignore the ground and other background regions

Multi-Class Classification of Onion Dataset

We aim to classify the four classes: Basal Rot, Bulb rot Seed, Healthy and Damping off disease using the Densenet baseline mode.

The overall classification accuracy achieved is **78%**

Confusion Matrix



Few-shot classification of Onion Images

N-way-K-shot Classification:
N classes are chosen in each episode during training/testing, and in each episode K support images are used to learn an embedding function.

TRAIN set :

- Basal rot : 111 images
- Bulb rot seed : 304 images
- Damping off : 187 images
- Healthy : 101 images

NOVEL set:

- Iris yellow spot virus : 5 images
- Purple blotch disease : 9 images
- Anthracnose disease : 20 images
- Stemphylium blight : 48 images

Accuracy on new classes: **46 %**

Training:
N = 4
# of Support Set images per episodes (K) = 5
# of query set images per episodes = 5

Test:
N = 4
# of Support Set images per episodes (K) = 3
# of query set images per episode = 2

Conclusion : Poor few-shot performance using prototypical networks for few-shot learning

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Conclusion

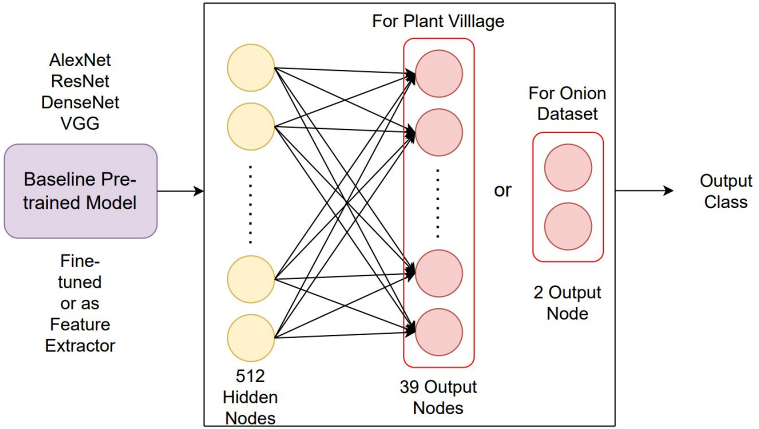
- Baseline CNN models give good accuracy numbers for Binary Onion Crop classification into healthy and diseased classes
- DenseNet121 model proves to be one of the best-performing models for binary classification achieving an accuracy of **92.4%** and occupying a memory size of only **29 MB**
- The cut mix data augmentation helps bring the classification's recall and precision to the same level, making the model robust to classifying both classes correctly without compromising on accuracy
- We achieve a multi-classification accuracy of around 74% to classify between three types of onion diseases and healthy onion images.
- Few-shot classification fails to generalize an embedding function for multi-class classification of different onion diseases

Summary

Aim : To classify healthy and diseased onion images taken from the field. Also to try a few-shot learning approach for multi-class classification of these diseases.

Method: Pre-trained baseline models tuned on Plant Village Dataset, then trained and tested on Onion image dataset.

Model



Results:

Model Name	Accuracy on Plant Village (%)		Model Size (in MB)
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ResNet18	94.8	97.2	44
ResNet50	95	98.1	94
ResNet152	96.1	98.9	226

Onion Dataset

Accuracy	0.924
Precision	0.65
Recall	0.93
F-score	0.767

DenseNet

Accuracy	0.90
Precision	0.59
Recall	0.833
F-score	0.6944

ResNet 152