Early plant disease detection by using transfer learning

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Problem Statement

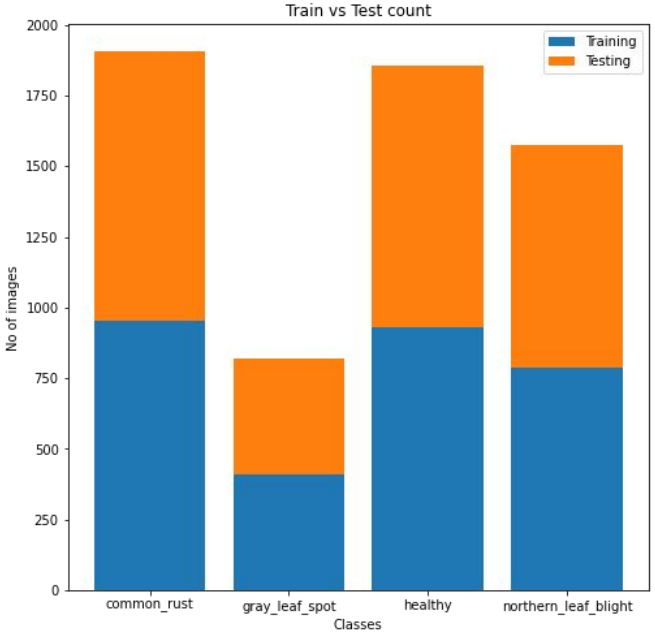
Plant disease has become a concerning issue nowadays. The annual worldwide crop loss has gone up to be USD 220 billion due to plant disease. This issue creates a huge impact on underdeveloped and developing countries, since they do not have enough resources to save crops from the fast spread of the disease.

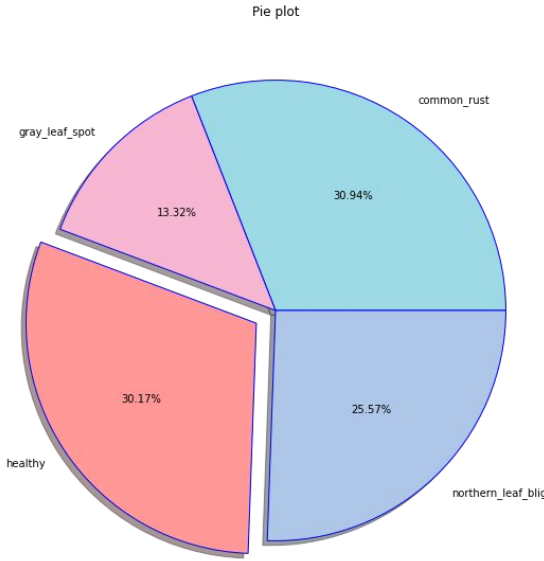
Thus, we propose

“Detecting and classifying corn (maize) leaves into one of four categories: healthy, northern leaf blight, common rust, and cercospora spot on gray leaf, using Transfer Learning."

EDA

- Performing EDA on the complete ‘Plant’ dataset, we concluded that Corn dataset is relatively balanced wrt to the other plant types.
- The ‘Corn’ dataset is a four-class problem.
- Total Images: 3852
- Train Test Split : 0.8 : 0.2
- Image shape : 224, 224, 3





Challenges Faced

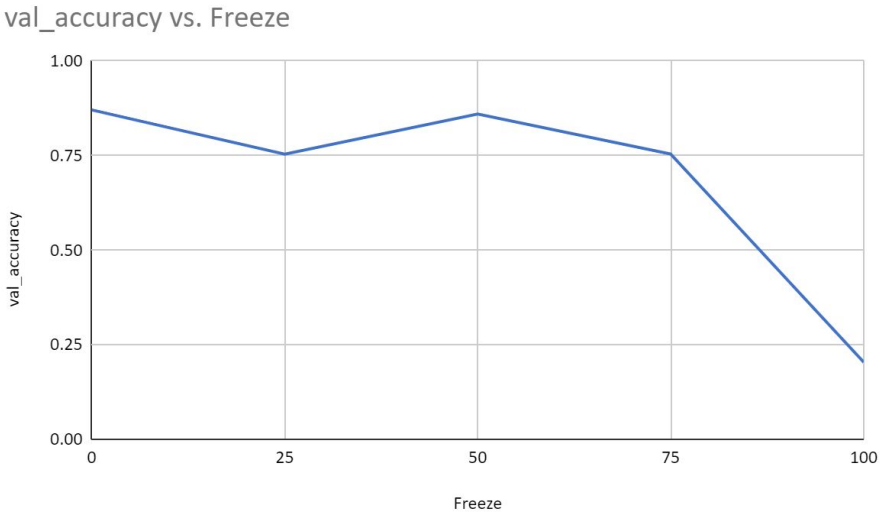
Type	Challenge	Solution
Imbalance Dataset	Count of '*gray leaf*' was quite less than others, thus our models underfit for the class resulting in low recall scores.	Performing undersampling.
Computational Constraints	During model training of 5 k folds for 100 epochs, google colab crashed	Purchased Google colab for long GPU hours.
Sudden fall of accuracy	During training, the accuracy would suddenly fall after certains epochs.	We shuffled the data to avoid any discrepancies and avoid sudden spikes.
Accuracy Flatline	The validation accuracies would go flatlined and model would not learn.	Tensorboard callbacks were used to recall the model in case of a flatline.

Models

- Transfer Learning Model : Mobile Net
- Strategies:
  - UnFrozen Layers
    - Layers UnFrozen 0, 25, 50, 100%
  - UnFrozen Ratio
    - Neurons Unfrozen 0.25, 0.5, 0.75, 1.00
  - Threshold
    - Validation Loss < 1.00
    - Validation Accuracy > 0.90
- K-Folds : 5
- Epoch : 100
- Total models trained: 15

Results : Frozen Layers

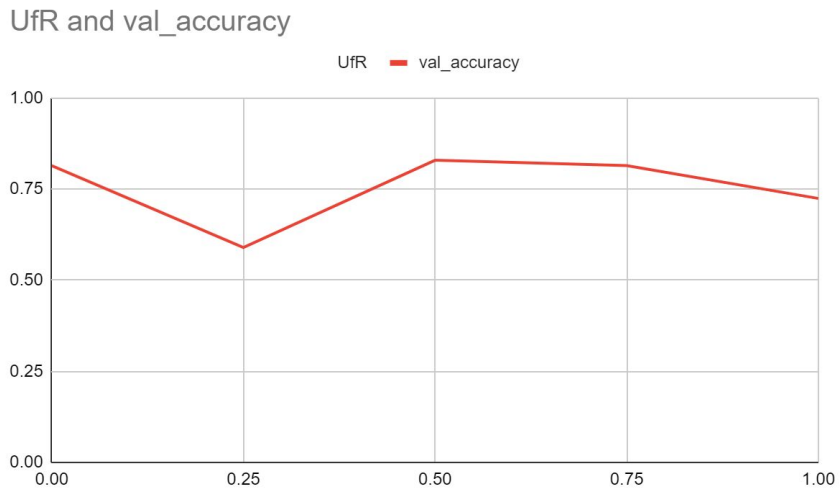
Freeze Layers	loss	accuracy	val_loss	val_accuracy
0	0.0137	0.9960	1.2327	0.8706
25	0.0258	0.9916	3.0844	0.7540
50	0.0089	0.9969	0.9286	0.8597
75	0.0202	0.9939	3.7221	0.7542
100	2.1003	0.2358	1.8737	0.2038



- Thus we can see for 0 frozen layers, the pre trained mobile net model has highest accuracy in 100 epoch training.

Result : Unfreeze Ratio

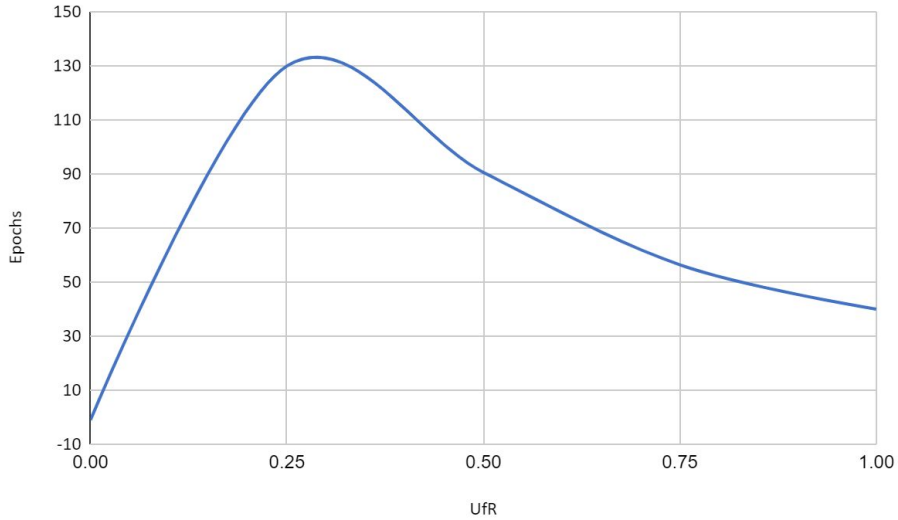
UfR	loss	accuracy	val_loss	val_accuracy
0	0.0187	0.9945	3.4643	0.8142
0.25	0.0087	0.9970	18.8112	0.5898
0.5	0.0069	0.9983	2.1671	0.8290
0.75	0.0187	0.9945	3.4643	0.8142
1	0.0209	0.9941	2.8116	0.7244



- Thus we can see for unfrozen ratio of 0.50, the model has highest validation accuracy for training of 100 epochs.

Results : UnFreeze Ratio Threshold

UfR	loss	accuracy	val_loss	val_accuracy	Epochs
0	2.08111	0.2374	1.8555	0.2512	-1
0.25	0.0067	0.9985	0.7447	0.9101	130
0.5	0.0100	0.99714	0.8498	0.9111	90.6
0.75	0.01491	0.9959	0.5534	0.9212	56.4
1	0.0085	0.9967	0.5659	0.9197	40



- Threshold:
  - Validation accuracy > 0.9
  - Validation loss < 1.0
- We can see that by fixing a threshold, the number of epochs to reach the threshold is highest for unfreezed ratio = 0.25

Under Sampling

Fold	loss	accuracy	val_loss	val_accuracy
1	0.000872	1	0.723708	0.929268
2	0.003627	0.999187	0.769076	0.912195
3	0.001601	1	0.643365	0.934146
4	0.022957	0.991057	0.693433	0.914634
5	0.014172	0.994309	0.654609	0.919512

- We undersample all data to: 410
- As we have a pre trained network, after undersampling the recall for gray leaf spot class does improve.

	precision	recall	f1-score	support
0	0.992	0.894	0.94	234
1	0.976	0.994	0.984	238
2	0.72	0.866	0.782	103
3	0.894	0.866	0.878	197
accuracy			0.914	772
macro avg	0.896	0.906	0.896	772
weighted avg	0.926	0.914	0.916	772

Conclusion

- From all the models trained we can conclude that the model with unfrozen ratio 0.5 performs well.
- However, after having a threshold, the model with an unfrozen ratio of 0.75 did outperform the rest models.
- But in this case, the recall value for class 2 is substantially lower than for other classes.
- This issue was resolved using Undersampling, which has high recall scores for all classes.

- Best models:
  - Frozen Layers: 0 layers freeze (All unfrozen)
    - Val Loss:1.232747465
    - Val Acc: 0.8706493735
  - Unfrozen Ratio:
    - Ratio: 0.5
    - Val Loss: 2.1671276
    - Val Acc: 0.829091
  - Unfrozen Ratio with Threshold:
    - Ratio: 0.75
    - Val Loss: 0.5534560919
    - Val Acc: 0.9212987065
    - Epochs: 56.4
  - Undersampling:
    - Ratio: 0.75
    - Val Loss: 0.7328595161
    - Val Acc: 0.908292675

Thank You