Image based Plant Disease Detection

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I. Problem Statement and Motivation

Farmers face several challenges due to plants being affected by diseases which leads to a dip in crop production. Early detection of the disease can aid the farmers in taking the right action.

II. Related Work

According to David Hughes et.al the detection of leaf disease depends on the type of image we are working on. Types: colour, grayscale, segmented.

The initial paper about plant disease detection and classification using deep learning – they experimented on above types of images and trained using Transfer learning and from scratch.

For Transfer learning they have taken pre-trained models of AlexNet and GoogLeNet and done training on above images and reported the results.

For Training from Scratch they trained on AlexNet and GoogLeNet architecture on above images and reported the results.

III. Dataset

We have taken the PlantVillage dataset[1]. This dataset has total of 55020 images and 38 classes. Each class label is a disease name of the crop. The dataset has healthy and diseased crop images in pairs. Each image is of dimension 256x256x3.

IV. Pre-Processing the dataset

As each data sample is 256x256x3, we have done different pre-processing steps on dataset for different architectures.

Initially we have 38 classes of leaf images which are specific to healthy and diseased images. But we don't have data which don't have leaf images. So, added a new class where images don't have no leaf in them which is considered as background class.So finally, we have a total of 39 classes in our dataset.

For SVM, we converted image to gray-scale and resized to 128x128 and 28x28 for computation convenience and normalized the dataset.

For Neural Network converted the image to gray-scale, resized to 28x28, 128,128 using interpolation method and normalized the dataset.

For CNN architectures, converted images to gray-scale, resized images to 224x224 as AlexNet,GoogLeNet etc. are required minimum of 224x224 image dimensions. Later converted to tensors and normalized the images using mean and standard deviation.

V. Novel approach to pre-processing

As the dataset is moderately small. We tried to do data augmentation using GAN, but we got very less quality images. so , we have used publicly available Augmented dataset[2] which is augmented using classical image processing technique like rotation, translation, segmentation.

VI. Challenges faced

As we are training our model on classical technique like SVM and deep learning technique like CNNs, they take a lot of time in training.

For SVM, our dataset contains more than 44000 images and each image is of 128x128, 28x28 dimensions. So after ravel it is of large dimensions. We applied RBF kernel which transforms the input domain to feature domain which is time consuming and computationally expensive and requires high system configuration. So, we are not able to run on different datasets and augmented dataset.

For CNNs, we used AlexNet, GoogLeNet which are 7layers and 22 layers respectively. While training they have taken long duration for an epoch. So, we are unable to experiment on different augmented dataset and unable to fine tune the network.

VII. Methodology

We implemented the Convolutional Neural Networks both from scratch, as well as used the pre-trained weights for the models trained on Imagenet dataset. We implemented AlexNet and GoogLeNet. The accuracy was comparable to that of the baseline paper, although, trained on lesser training iterations.

We then used the augmented dataset to generate different augmentations of the infected leaves. We also run the models on the augmented dataset.

We then used a multi-task network, which does both infected leaf classification and leaf type classification. The dataset had been arranged accordingly. We obtained better performance on the same with lesser number of iterations.

We also tried using GAN-based approaches to generate infected leaves. However, the performance is not upto the mark.

VIII. Analysis

We infer from the observations we made that plant disease classification based on the images available requires a better approach than the traditional image classification techniques. It is because the leaves are generally in similar shapes. Unless the leaf structures are distinctly different, it leads to a considerable level of misclassification, which is not desirable. Therefore, it is important to classify the type of leaf first, then use it to classify the type of disease. Although we tried to implement the same in our work, we think we could have a network that first classifies the image and only then classifies the disease based on what diseases can affect the plant. Backpropagating loss to a single parent architecture could be modified to contain a serial network.

IX. Models, Results and Inferences

We experimented on different architectures- AlexNet, GoogLeNet by using transfer learning and from scratch and plotted the results and compared with our base paper accordingly.

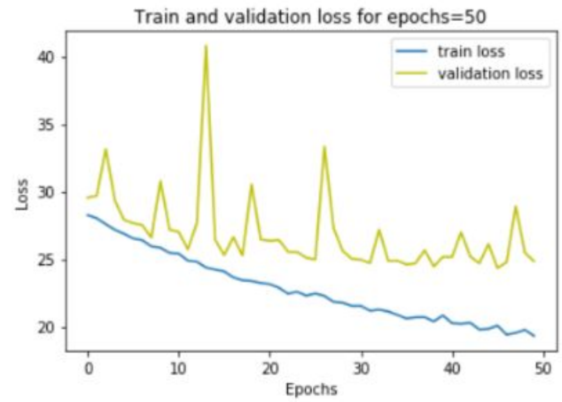
We have evaluated our model on the basis of metrics - Accuracy, Precision, Recall, F1-Score.

Model	Base paper Result	Our Result
SVM with RBF kernel	-	0.83
AlexNet with Transfer learning	0.97	0.91
AlexNet from Scratch	0.9118	0.87
GoogLeNet using Transfer Learning	0.9820	0.92
GoogLeNet from Scratch	0.9430	0.89

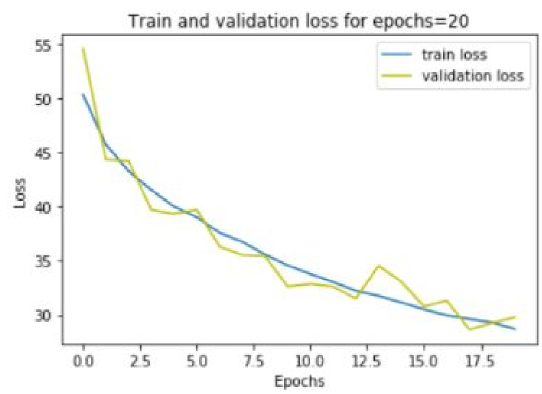
Table: Results and comparison on Accuracy

In our base paper, they trained on different dataset size like 80:20, 70:30 etc. and reported the results.In our implementation, we took the train and test set different and trained the network.

A. Neural Network:



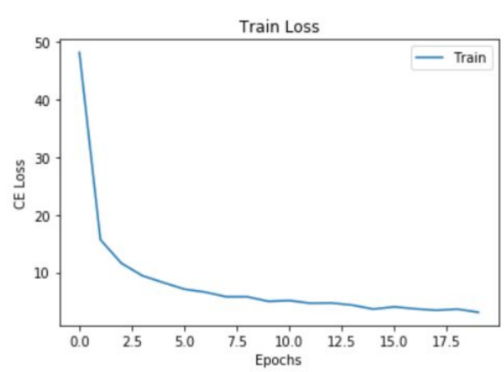
CNN without augmentation

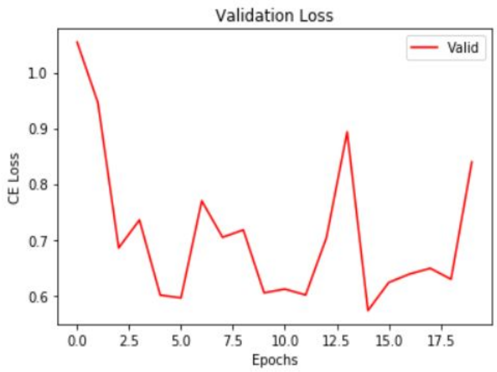


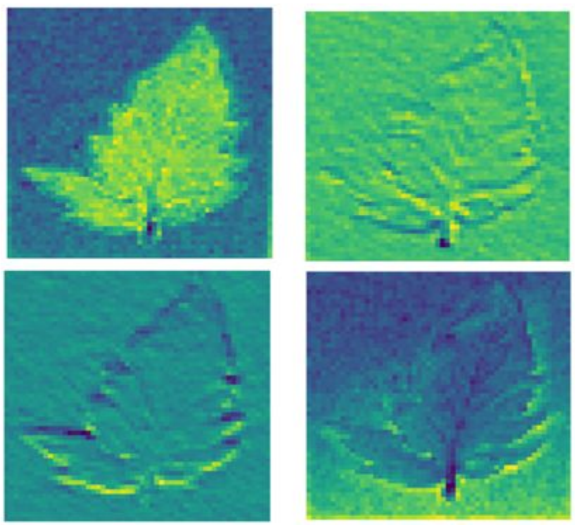
CNN with augmentation

B. AlexNet:

The loss for AlexNet converged well but the validation loss fluctuated. The plots for the same can be as seen below:



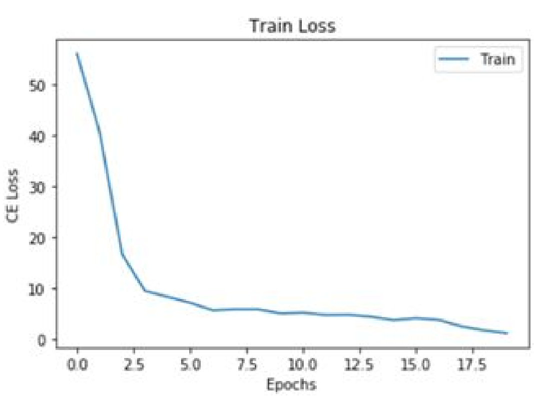


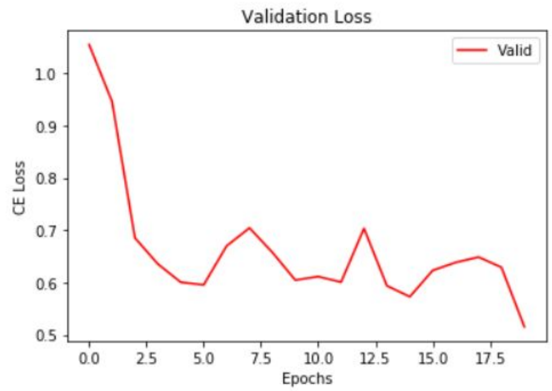


Activation map output of first convolutional layer

C. GoogLeNet:

The loss for GoogLeNet converged well and the validation loss as converged better than AlexNet. The plots can be as seen below:

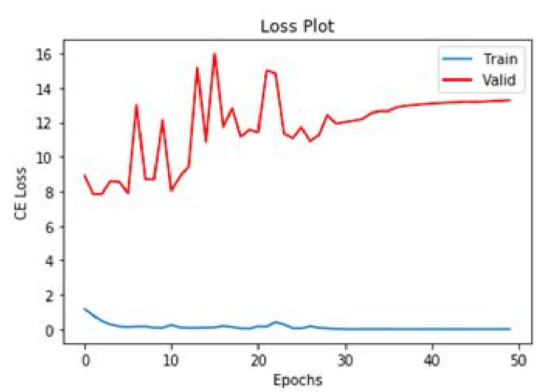




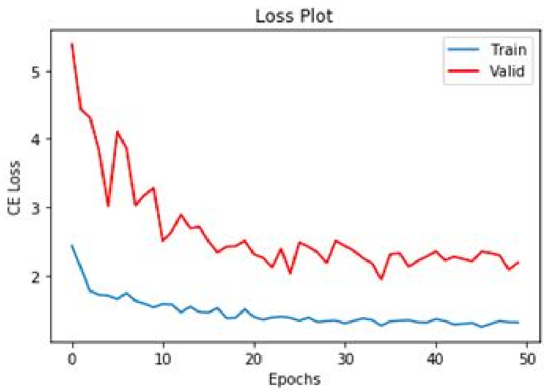
D. Multi-Task Learning:

For novelty we experimented on Multi-task learning. For this, we trained two models, one is only disease classification and another one is multi-task learning based model i.e., leaf classification + plant disease classification.We compared those results and inferred that multi-task learning is converging better than normal detection model.

We can see that the loss for Leaf+Disease detection converged well and the train-validation loss gap is less compared to plain classification.



Disease Detection



Leaf + Disease classification

X. State-of-the-art

As earlier works were done on different set of datasets, this problem statement don't have any State-of-the-Art. Most of the previous works were used classical machine learning techniques like SVM and CNN architectures like AlexNet and GoogLeNet on different datasets.

XI. Deliverables

We developed a model that detects the plant disease based on images and experimented on different architecture and analysed.

We tried novel approaches like GAN for data augmentation and implemented Multi-task learning for leaf detection and disease detection.

XII. REFERENCES & CITATIONS

[1]. PlantVillage dataset: from kaggle https://www.kaggle.com/emmarex/plantdisease

[2]. New PlantVillage dataset: from kaggle https://www.kaggle.com/vipoooool/new-plant-diseases-dataset

[3]. Using Deep learning for Image based Plant Disease Detection. SP Mohanty et.al.

[4]. An In-field Automatic Wheat Disease Diagnosis System.Jiang Lu et.al.

[5]. Deep Learning in Agriculture: A Survey.,Andreas Kamilaris et.al.

[6]. Identification and Recognition of Rice Diseases and Pests Using Convolutional Neural Networks.,Chowdhury Rafeed Rahman et.al.

XIII. Individual Contributions

Both contributed equally to each component.