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Vegetable Leaf Disease Detection Using Deep Learning

ABSTRACT
With increase in population the need for food is on rise, in such circumstances, plant diseases prove to be a major threat to agricultural produce and result in disastrous consequences for farmers. Early detection of plant disease can help in ensuring food security and controlling financial losses. In this project, we train a deep convolutional neural network to identify 5 different crop species and 10 disease, which are affecting the farmers adversely. If a farmer can detect these disease at early time and apply appropriate treatment then it can save lot of waste and prevent their economic losses too. We have used public dataset of 17,055 images of diseased and healthy plant leaves collected and filtered according to the requirements. The trained model achieves an accuracy of 93.22% upon training these datasets. We are proposing the web application which will detect the disease of the 5 different crop species disease.

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I. INTRODUCTION

Rapid population growth over recent decades has resulted in an increased demand for agricultural goods, which in turn has lead to a large expansion of cultivation. To meet rising population demands for food, bio-fuels, and animal products, crop yield production must double its output by 2050. In order to achieve this goal, key crop yields must improve by 2.4% each year, but they are now only increasing by roughly 1.3% per year.

The agriculturist in provincial regions may think that it's hard to differentiate the problem or disease which may be available in their harvests. In India, agriculture has become important source of the economic development. Farmer selects the suitable crop based on type of soil, weather condition of the location and economic value. The agriculture industries started searching new methods to increase production of food because of increasing population, changes in weather. This makes researchers to search new efficient and precise technologies for high productivity. Making use of analysis and detection processes using present technology helps the farmers to get rid of such problems. During pandemic situations like COVID 19 the nation is dependent on the recent technologies to prevent address the issues to reduce the transmission of the diseases.

Pests and Diseases results in the destruction of crops or part of the plant resulting in decreased food production leading to food insecurity. Also, knowledge about the pest management or control and diseases are less in various less developed countries. Toxic pathogens, poor disease control, drastic climate changes are one of the key factors which arises in dwindled food production.

Various modern technologies have emerged to minimize postharvest processing, to fortify agricultural sustainability and to maximize the productivity. Several factors of these technologies being high resolution camera, high performance processing and extensive built in accessories are the added advantages resulting in automatic disease recognition. However, these techniques are not cost effective and are high time consuming. Modern approaches such as machine learning and deep learning algorithm has been employed to increase the recognition rate and the accuracy of the results. Leaf diseases vary in shape, size, and colour. Certain diseases might have the identical colour, but dissimilar shapes; while some have dissimilar colours but identical shapes. The model can be developed by capturing the diseased leaves and recognize the patterns about the disease is helpful to get free of crop loss . There are the different innovations. Farmers will benefit from the introduction of automated disease detection tools. This approach yields outcomes that are suitable for both little and large-scale agricultural cultivation. Importantly, the results are precise, and the disorders are detected in a very short amount of time. These technologies rely heavily on deep learning and neural networks to function.

With the improvements in technology, automatic detection of plant diseases from raw images is possible through computer vision and artificial intelligence researches. In this study, the researchers were able to investigate plant diseases and pests infestation that affects the leaves of the plants. The introduction of deep learning methods turns out to be popular. Deep learning is the advanced methods of machine learning that uses neural networks that works like the human brain Traditional methods involve the use of semantic features as the classification method. A convolutional neural network (CNN) is a deep learning model that is widely used in image processing. The work of Lee et al. presents a hybrid model to obtain characteristics of eaves using CNN and classify the extracted features of leaves. The methodology in the study involves three key stages: acquisition

of data, pre- processing of data and image classification. The study utilized dataset from Plant village dataset that contains plant varieties of bell pepper, corn, cassava, potato, and tomato. There are 15 types of plant diseases identified in the study including healthy images of identified plants. Image pre-processing involves re-sized images and enhancement before supplying it for the training.

Deep Convolutional Neural Network is utilized in this study to identify infected and healthy leaves, as well as to detect illness in afflicted plants. CNN is used to extract features from images i.e. horizontal edges, vertical edges, RGB values etc. The CNN model is designed to suit both healthy and sick leaves; photos are used to train the model, and the output is determined by the input leaf.

II. OBJECTIVE AND METHODOLOGY

OBJECTIVE

Our aim is to prevent the wastage of crop as it needs lot of effort to grow a crop and wastage never worth it. It will also help the farmers to prevent from financial losses. As the accessibility to reach the correct department to analyse the disease in the crop is very limited, so we will help our farmers to find the solution by their own. It will definitely deal with the problem of food insecurity in the country. The better accuracy of identification of disease is our primary aim with our best working model.

III. METHODOLOGY

1. Dataset Discussion

We will collect the different healthy and unhealthy pictures of 5 plant crop species from the online platform and classify the dataset. After that we will use train the dataset with CNN(Convolutional Neural Network) model. We will use Fast API framework to work with the real time image of the potato, tomato, corn, cassava, bell pepper crop disease to identify, it contains any disease or not.

Dataset consists of 15 classes with healthy and unhealthy plant leaves with a total number numbers of 17,055 images. It is also openly available on internet.

Class	**Plant Name**	**Healthy or Diseased**	**Disease Name**	**Images(Number)**
0	Bell Pepper	Diseased	Bell Pepper Bacterial spot	1496
1	Bell Pepper	Healthy	-	1137
2	Cassava	Diseased	Cassava Bacterial Blight	781
3	Cassava	Diseased	Cassava Green Mottle	1507
4	Cassava	Diseased	Cassava Mosaic Disease	1476
5	Cassava	Healthy	-	370
6	Corn	Diseased	Corn Common rust	1528
7	Corn	Diseased	Corn Gray leaf spot	1491
8	Corn	Healthy	-	1104
9	Potato	Diseased	Potato Early blight	1000

10	Potato	Healthy	-	152
11	Potato	Diseased	Potato Late blight	1000
12	Tomato	Diseased	Tomato Early blight	1542
13	Tomato	Healthy	-	971
14	Tomato	Diseased	Tomato Late blight	1500
Total			17,055	

IV. CONVOLUTION NEURAL NETWORK

Deep learning is considered to be subset of machine learning which uses Artificial Neural Networks to learn the features from data and infer rules. Today there is huge demand of deep learning in almost every field from banking for fraud detection to mobile phones, AI proctored examination, speech and video analysis, etc.

Convolutional neural networks are another type of neural network which differs from ANN in the fact that it makes use of convolution operation to be applied on dataset. CNN are highly effective in learning the features from data like- images and infer weights and biases which in future are used for prediction. Input layer, CONV layer, pooling layer, and fully connected layer are the four layers that make up a CNN.

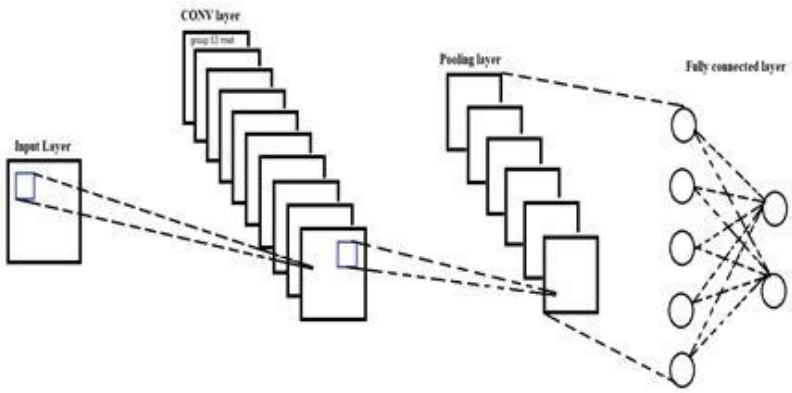
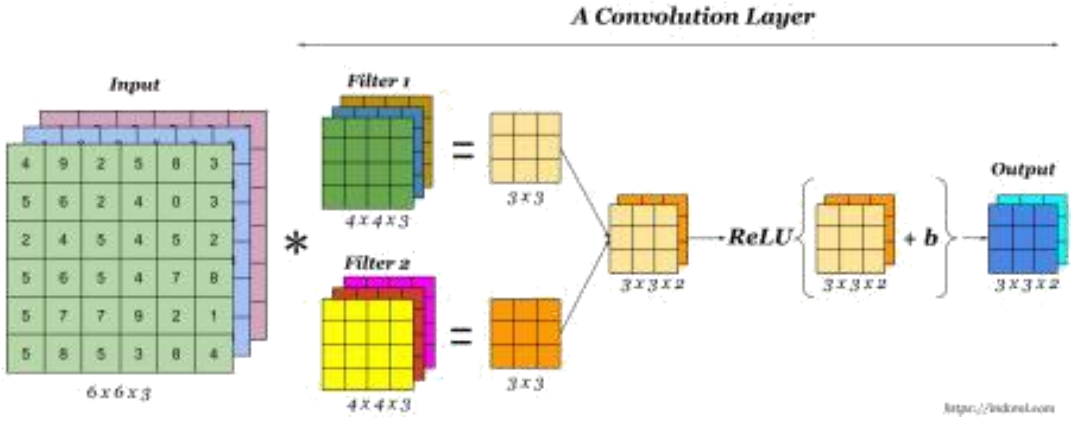


Fig. 1

a) CONVOLUTION LAYER

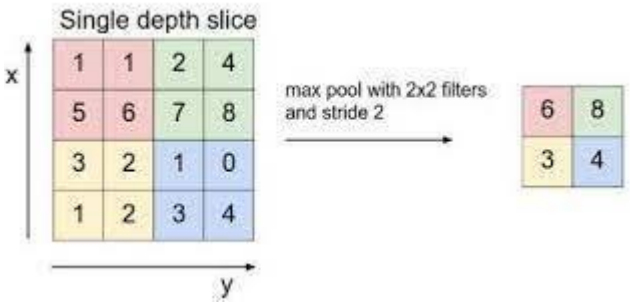
Convolutional layers are the major building blocks used in convolutional neural networks. A convolution is the simple application of a filter to an input that results in an activation. Repeated application of the same filter to an input results in a map of activations called a feature map, indicating the locations and strength of a detected feature in an input, such as an image.

The innovation of convolutional neural networks is the ability to automatically learn a large number of filters in parallel specific to a training dataset under the constraints of a specific predictive modelling problem, such as image classification. The result is highly specific features that can be detected anywhere on input images.



b) POOLING LAYER

Pooling layers are **used to reduce the dimensions of the feature maps**. Thus, it reduces the number of parameters to learn and the amount of computation performed in the network. The pooling layer summarises the features present in a region of the feature map generated by a convolution layer.



The purpose of the pooling layers is to reduce the dimensions of the hidden layer by combining the outputs of neuron clusters at the previous layer into a single neuron in the next layer.

c) RELU FUNCTION

As a consequence, the usage of Relu helps to prevent the exponential growth in the computation required to operate the neural network. Relu stands for Rectified Linear Unit. The main advantage of using the Relu function over other activation functions is that it does not activate all the neurons at the same time. If the CNN scales in size, the computational cost of adding extra Relu increases linearly

RELU FUNCTION GRAPH

d) ACCURACY CALCULATION

Accuracy is a metric that generally describes how the model performs across all classes. It is useful when all classes are of equal importance. It is calculated as the ratio between the number of correct predictions to the total number of predictions.

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

For binary classification, accuracy can also be calculated in terms of positives and negatives as follows:

$$\boldsymbol{Accuracy} = \frac{\boldsymbol{True_{positive} + True_{negative}}}{\boldsymbol{True_{positive} + True_{negative} + False_{positive} + False_{negative}}}$$

METHODOLGY STEP BY STEP

The steps are as follows:

1. Dataset acquisition or collection

The image dataset for training the model was obtained from a variety of open source sites, including the plant village dataset. Images were manually downloaded and organized into folders based on their appropriate classifications. Here we have taken 5 different classes (with some example):

a) Bell pepper(bacterial_spot, bacterial_healthy)


Bacterial spot Healthy

b) Cassava(Bacterial_blight, green_mottle, mosaic_disease, healthy)


Bacterial blight green mottle


Mosaic disease Healthy

c) Corn(common_rust, gray_leaf_spot, healthy)



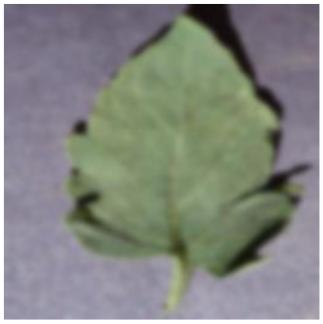
Common Rust Gray leaf spot Healthy

d) Potato(early_bight,healthy,late_blight)



Early blight Healthy Late blight

e) Tomato(Early_blight,healthy,late_blight)

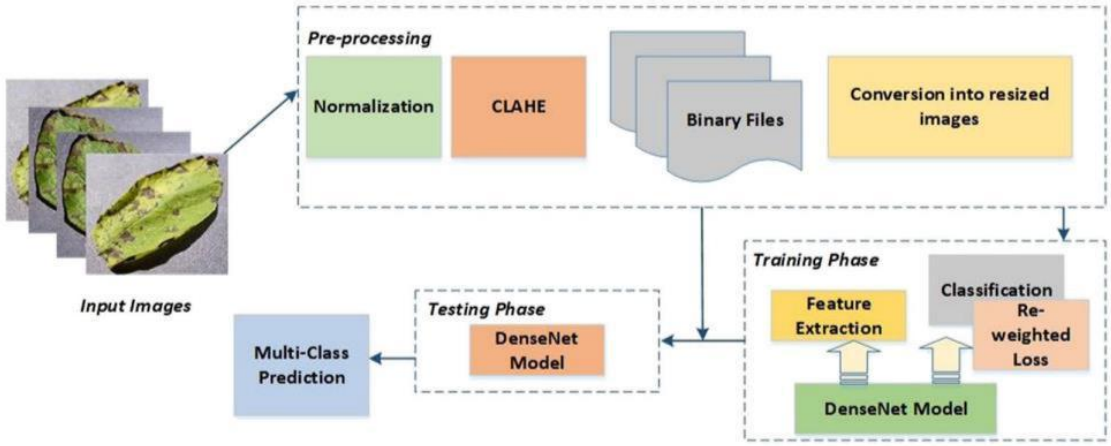

Early Blight Healthy Late

2. Image Pre-processing

Photos were pre-processed to minimize their size in order to match the input layer's input criteria. Colored 256 X 256 resolution images are used in this study.

3. Model Building

A typical CNN model was built to train and test the data. CNN model design also plays a vital role in the final accuracy and other results.



4. Training

The proposed model was trained using the pre-processed dataset for about 40 epochs.

Parameter	Value
Epochs	40
Batch Size	32
Activation in middle layers	Relu
Activation in Final layer	Softmax

5. Classification

First features are extracted from input images using CONV and pooling layers and then classification is done using fully connected layers.

V. RESULT AND CONCLUSION

RESULT

During the training of deep learning model, 40 epochs were used to train the model which attained a accuracy rate of 93.22%. While testing on random image samples, the model successfully reached a maximum accuracy rate of 89.75%. Our project will help the farmers to easily identify the disease of leaf. It will be very convenient to use as they don't have to worry about moving to another area for the search of people to successfully analyse the disease of the leaf. It will prevent the financial loss of the farmers. More importantly, there will be the proper defence for the threat of food insecurity in the society or in country. There may be imbalance of supply chain in the market which may cause the hike of the product cost drastically.

CONCLUSION

Our proposed solution will add values to the society and help the farmers to know the accurate disease of the potato, tomato, corn, cassava, bell pepper and hence can cure the disease more accurately and prevent from the financial losses and also prevent wastage of crop. Our application is made with user friendly and predict the disease more accurately.

FUTURE SCOPE

Nowadays, It is very important to detect a disease in a plant in the budding stage so that productivity and quality of the yield can be upgraded. Since disease detection needs a lot of expertise so it would be very beneficial if we could implement this system on the smartphone in which farmers can click a picture of the leaf and send it to the server.

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