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Early-Stage Plant Disease Prediction Using Multilayer Convolutional Neural Network Framework

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ABSTRACT
Crop diseases are a major risk to food security, but its identification is difficult due to lack of infrastructure. Detecting and Identifying disease from the plants images is one of the interesting research areas in computer and agriculture field. The main objective in this paper is to help farmers to identify the disease and to prevent the plants in early stage. Plant disease recognition model, based on leaf image classification, developed using convolutional neural network. The developed model trained from scratch to identify the disease and it is able to recognize 10 different types of plant diseases. The reason for choosing CNN is CNN Classifier algorithm mainly extracts more features from the image datasets rather than other classifier algorithms. The trained model achieves an accuracy of 97%.

Keywords: Detecting, Recognition, Leaf image, Convolutional neural network.

1. INTRODUCTION

In Asian country concerning seventieth of the population depends on agriculture. Farmers have large range of diversity for choosing numerous suitable crops and finding the suitable disease of plant. Due to the environmental changes condition such as Rainfall, Temperature, Soil fertility, etc., the crops are get infected by fungi, bacteria and viruses. Leaves being the foremost sensitive part of the plants that show disease symptoms at the earliest. The crops have to be compelled to be monitored against diseases from the initial stage of their life-cycle to the time they are ready to be harvested. Initially, the method used to monitor the plants from diseases was the traditional naked eye observation that is a long technique which needs specialists to manually monitor the crop fields. Within the recent years, a variety of techniques have been applied to develop automatic and semi-automatic plant disease detection systems and automatic detection of the diseases by simply seeing the symptoms on the plant leaves makes it easier further as cheaper. These systems have so far resulted to be quick, cheap and more accurate than the standard method of manual observation by farmers.

Image processing is a branch of signal processing which can extract the useful information from the image. We need a large amount of verified dataset of images of diseased and healthy plants. There are several cases wherever farmers don't have a fully compact knowledge about the crops and the disease that may get affected to the crops. This paper will be effectively used by farmers thereby increasing the yield instead of visiting the skilled and obtaining their recommendation.

The main objective is not only to detect the disease by using image processing technologies. It also directs the preventive measures of the plant disease and the user directly to an e-commerce website wherever the user should purchase the medicine for the detected disease by comparing the rates and use suitably consistent with the directions given. In this paper, we have described the technique for the detection of plant diseases with the help of their leaves pictures and providing the introductory information to image processing techniques it may be used to detect various plant diseases.

2. RELATED WORK

Agricultural production of the world sustains annual loss of about 20 to 30% on an average due to plant diseases indifferent countries and in different crops. In the greater part of the cases, the misfortunes rise even to 100% or when no control measures are attempted if there should be an occurrence of some significant infections. Plant illnesses are considered as one of the significant bottlenecks in Farming in inundated harvests, in monoculture developments and in certain generally developed rain fed crops also. To keep away from such misfortunes, in this manner, it is important to know in detail plants and their infections.

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Under given ideal conditions for plant development that is soil type, environment and nourishment, the yields are normally influenced by two undesired variables for example illnesses as well as pests.

Zulkifli Bin Husin in their paper performed early detection of chili disease through leaf features inspection. Leaf image is captured and processed to determine the health status of each plant. Their technique is ensuring that the chemicals should apply to the diseased chilli plant only. They used the MATLAB for the feature extraction and image recognition [1]. Halil Darmus, anticipated a deep learning approach to identify a variety of diseases on the leaves of tomato plants. Two different pre-trained deep learning network architectures namely Alex Net and Squeeze Net were used. Nvidia Jetson TX1 was employed to train and validate the architecture. Plant Village dataset with tomato leaf images has been used for training. It is shown that Squeeze Net is a good architecture for the mobile deep learning classification [2].

Guan Wang , had taken the Plant Village dataset with the apple black rot images of four severity stages and used deep convolutional neural networks to identify the complexity of the disease. The performance of both the shallow and deep network model is evaluated. The author mentioned that the best model is the deepVGG16 model which provides an overall accuracy of 90.4% [3]. Pooja V et al., had showcased algorithms of machine learning and performed image processing for identifying transited portion of the plants where they found SVM exhibited better results than previous plant disease detection techniques and their plant disease recognition rate reached 92.4% in terms of accuracy [4].

3. METHODOLOGY

3.1 Convolutional neural network

The convolutional neural network (CNN) is a class of deep learning neural networks which helps to extract important features from the images. It is represent a huge breakthrough in image recognition. It has an intricate network structure and can perform convolution tasks. The convolutional neural network model is made out of information layer, convolution layer, pooling layer, full association layer and yield layer. In one model, the convolution layer and the pooling layer substitute a few times, and when the neurons of the convolution layer are associated with the neurons of the pooling layer, no full association is required. CNN is a well known model in the field of deep learning. The explanation lies in the enormous model limit and complex data achieved by the fundamental primary qualities of CNN, which empowers CNN to play a benefit in picture acknowledgment. Simultaneously, the achievements of CNN in computer vision undertakings have supported the developing prevalence of deep learning.

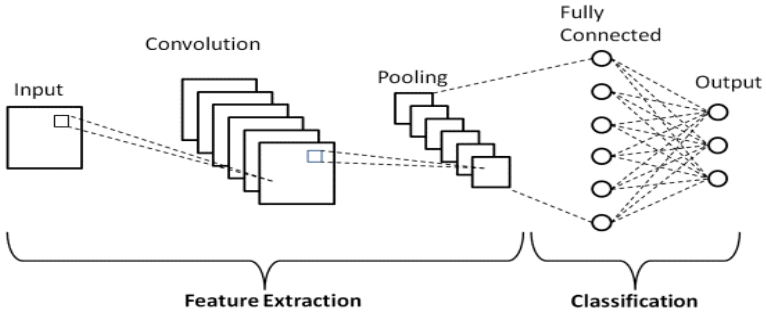

Figure 1: Architecture of CNN Algorithm

CNN Layers:

1. Convolution Layer:

In convolution operation, the input image is convold with feature detector or filter to induce a feature map. Convolution is the simple application of a filter to the input that results in activation. Repeated application of the constant filter to an input ends up in a map of activations called a feature map. The important role of feature detectors is to extract the important feature from the image. One single image convold to different filter to avoid unwanted information and to extract all the important features. By applying convolutional operation the size of the operation image is reduced. Due to that, we may loss some important features but feature detector/filter will helps us to extract main features from the image and remove unwanted features. A feature map can be build by comparing the input image with the filter is called as convolution layer [5].

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2. Max-pooling:

In this method, Max pooling is a type of operation that is typically added to CNNs following individual convolutional layers. This is not sustainable because of the large computing resources it demands. Max pooling reduces the dimensionality of images by reducing the number of pixels in the output from the previous convolutional layer. At the same time, we need enough convolutions to extract important features. Max Pooling is a convolution process wherever the Kernel extracts the maximum value of the area it convolves. It is used to avoid spatial invariance and distortion [6]. It is also used to avoid overfitting of the data. By adding max-pooling operation we are neglecting 75% of unwanted information. When pooling is applied to a feature map is called pooled feature map. A group of pooled feature maps is called pooling layers.

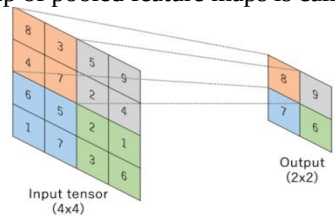

Figure 2: Max-pooling

3. Flattening Layer:

Flattening is converting the multidimensional layer into a single dimensional array for inputting it to the next layer. After finishing the previous two process, we are supposed to have a pooled feature map by now. As the name of this step implies, we are actually going to flatten our pooled feature map into a column like within the image below. We tend to flatten the output of the convolutional layers to form a single long feature vector. And it's connected to the final classification model, that is termed a fully-connected layer. It is the input layer of ANN (Artificial Neural Network) [7].

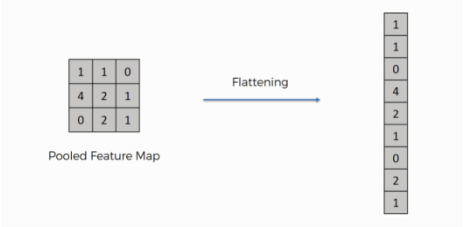

Figure 3: Flattening Layer

4. Fully Connected Layer:

Fully connected layers in a neural networks, where all the inputs from one layer are connected to each activation unit of the next layer and it performs classification based on the extracted features [8]. The output feature maps of the final convolution or pooling layer is often flattened, i.e., it transformed into a one-dimensional (1D) array of numbers (or vector), and connected to at least one or more fully connected layers, also known as dense layers. The feature maps are extracted by the convolution layers and down sampled by the pooling layers are created, they're mapped by a subset of fully connected layers to the final outputs of the network, like the probabilities for every category in classification tasks. The fully connected layer generally has the same number of output nodes as the number of classes. Each fully connected layer is followed by a nonlinear function, like ReLU, Softmax, etc.

3.2 Artificial neural networks

Artificial neural network (ANN) is also called neural network (NN) are computing systems inspired by analogy of biological neurons, which is used to process the information as a human brain does. It is based on a collection of connected units or nodes called artificial neurons, which has to loosely model the neurons in a biological brain. An ANN use feed forward network while consists of different layers namely input layer, hidden layer and output layer. An Artificial Neural Network is basically an engineering approach of biological neuron. ANN has device with many inputs and one output. An ANN is consisting a large number of simple processing elements that are interconnected with each other and layered also. An ANN has hundreds or thousands of artificial neurons called recycling units, which are connected by bumps. These processing units are made from input and affair units. The input units admit colorful forms and structures of data supported an inner weighting system, and

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thus the neural network attempts to find out about the knowledge presented to supply one affair report. Just like humans need rules and guidelines to return up with a result or affair, ANNs also use a group of literacy rules called back propagation, an condensation for backward propagation of error, to perfect their affair results [9].

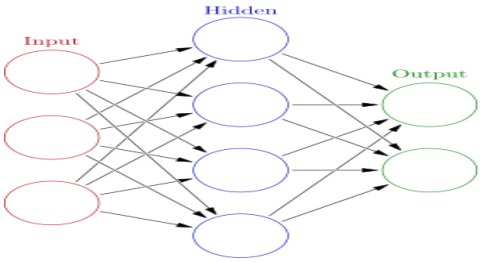

Figure 4: Artificial Neural Network layer

3.3 Deep learning theory

The fundamental thought of profound learning is utilizing neural network for information investigation and highlight learning, information highlights are separated by numerous secret layers, each secret layer can be viewed as a perceptron, the perceptron is utilized to remove low-level highlights, and afterward consolidate low-level highlights to acquire theoretical undeniable level highlights, which can essentially lighten the issue of neighborhood least. It has now been effectively applied in PC vision, design acknowledgment, discourse acknowledgment, characteristic language handling and proposal frameworks. Conventional picture arrangement and acknowledgment techniques for manual plan highlights can just concentrate the fundamental highlights, and it is hard to separate the deep and complex picture include data. Actually, profound taking in can consequently take in highlights from enormous information without manual control. The model is made out of various layers, which has great independent learning capacity and highlight articulation capacity, and can naturally separate picture highlights for picture arrangement and acknowledgment. Deep learning methods have developed several well-known deep neural network models, as well as deep belief network (DBN), deep Boltzmann machine (DBM), stack de-noising autoencoder (SDAE) and deep convolutional neural network [10]. As of late, the most famous profound learning system is profound convolutional neural network.

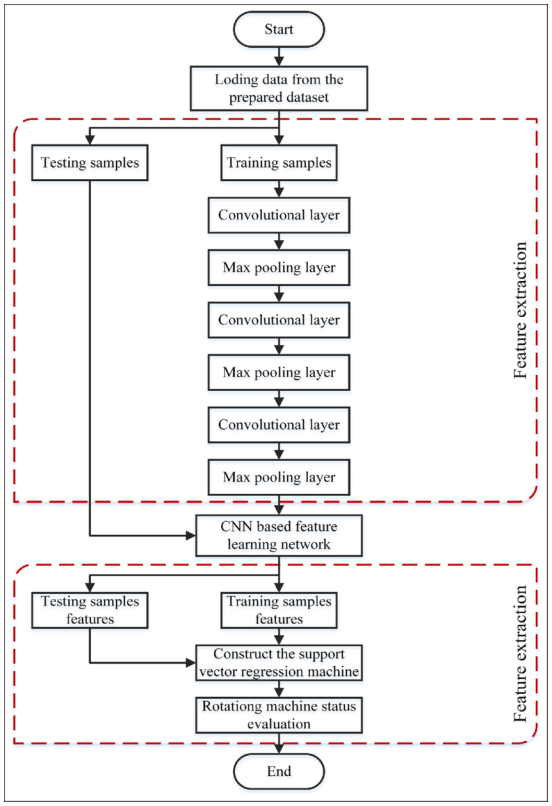

Figure 5: Flowchart of CNN

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Start the process with the collection of all the ten types of input disease images. The next step is pre processing, the collected images and setting up division parameters which is 30% for testing images and 70% for training images and the next step is to modifying the algorithm by adding different layers to increase the accuracy. Once required accuracy is achieved then save the algorithm as a h5 file and then save it into the folder where u have saved the template(html) and static(css) and then once you run the file output is achieved and stop the process.

3.4 Dataset

The first step is to store the collected data in an empty folder. The data for plant disease prediction is the leaf of the different plants. Inside the folder we've to make the train and test data. Once the data is collected we have to give the labels to the classes. The trained set should contain 70% of the data and test set is 30%.The dataset contain 10 different disease affected plants leaf. The architecture of a model is not the main factor that has got to be considered to get good accuracy. It is rather the standard of the training data also as its preprocessing and augmentation which will provide the foremost significant accuracy improvements. All steps associated with the preparation of the info must therefore be administered during a rigorous way. The annotation phase should begin by a particular definition of the category taxonomy, particularly if the contamination intensity is annotated. This step ensures the annotations reproducibility. Having quite one expert for annotation prevents the danger of dependence on the annotator. Otherwise, a picture and its transformation could find yourself in both training and validation sets, causing data leakage. Dealing with the category imbalance is additionally important for the convergence of the model and its.

Bacterial leaf blight-Rice

Cercospora leaf spot-Beet root

Cercospora leaf spot-brinjal

Brown spot-Rice

Blight leaf-Carrot

Blight leaf-Potato

Bacterial spot-Tomato

Late blight-Tomato

Leaf Mold-Tomato

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Septoria leaf spot-Tomato
Figure 6 : Different types of Leaf

3.5 Activation function:
An activation function is an important feature of an artificial neural network, they primarily decide whether or not the neuron ought to be activated or not. In this neural networks, the activation function defines the output of that node which given an set of inputs or an input.
ReLU - ReLU stands for the Rectified Linear Unit. Once the feature maps are extracted, the following step is to move them to a ReLU layer. This operation performs element-wise and sets all the negative pixels to 0. ReLU introduces a non-linearity to the network, and the generated output is rectified feature map [11].

$$f(x) = max\ (0, x)$$ -------- (1)

Softmax - Rather of using sigmoid, we will use the Softmax activation function in the output layer. The Softmax activation function calculates the relative chances. The softmax function would range the outputs for each class between 0 and 1. Related to the sigmoid activation function the SoftMax function returns the chances of each category. There is an equation for the SoftMax activation function [12].

$$softmax(z_i) = \frac{exp(z_i)}{\sum_j exp(z_j)}$$ ------- (2)

4. RESULTS ANALYSIS

Convolutional neural networks in deep leaning technique are used to detect and identify the infected plants by detecting the images of the plant leaf. It helps to extract the important features from the images and train them and predicts the output. In this model we have added the preventive measures of the infected plants. It provides chance to identify the disease at early stage. The main advantage is it has high accuracy.

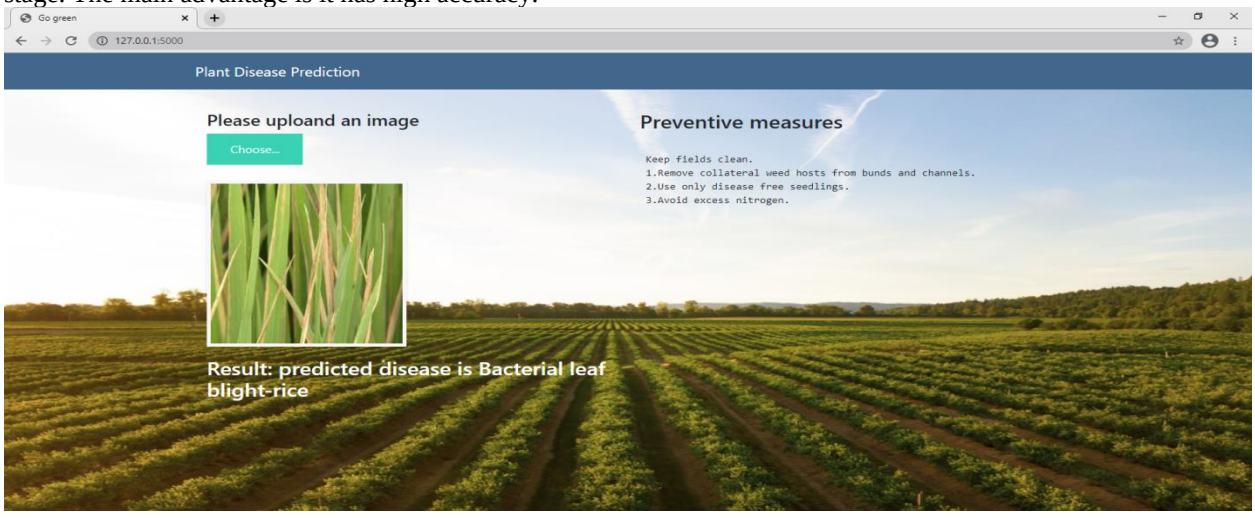

Figure 7: Webpage of prediction

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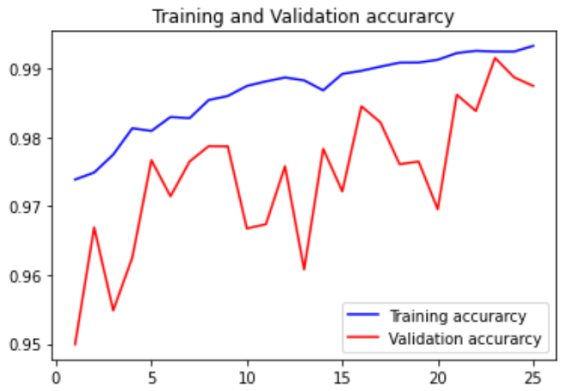
A diseased plant image has been uploaded and then it predicts. Figure 7 shows the Bacterial leaf blight–rice disease. For plant disease prediction, to collect dataset of plant images and label them or split them into train and test data set.



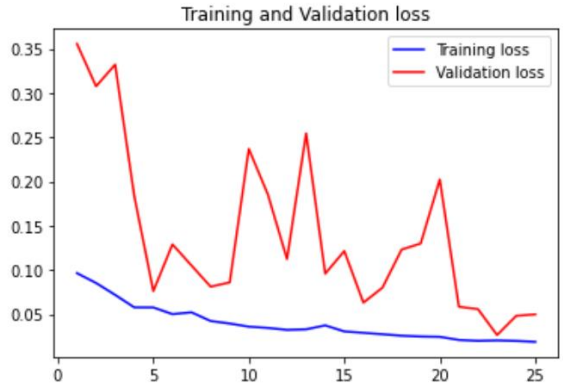


Figure 8: Training VS Validation Accuracy Figure 9: Training Vs Validation Loss

A graph has been plotted to compare the maximum accuracy achieved by the model whereas minimizing the loss throughout the training phase. Figure 8 shows the graph between validation and training accuracy and Figure 9 shows the graph between training and validation loss. To check the actual(test) accuracy of the model and it trained, the evaluate() method and obtain a test accuracy of 96.75%.

5. CONCLUSION

In this model we used images of the diseased plant as a dataset and trained them and predict the output. In this work a model for prediction of plant diseases is done by using deep learning algorithms. It is found that by using the ensembling features and deep learning we can achieve a higher accuracy rate and also we can go for the prediction of many more diseases. A number of irrelevant attributes are reduced through image rotation and image resizing are done in image pre-processing. The CNN based model is capable of detecting the disease of 10 plants with high accuracy and high training efficiency. A CNN model is saved and a UI is built using flask and HTML. The main characteristics of the disease detection are speed and accuracy. Hence there is working on development of fast, efficient and accurate system, which is use for detection disease on unhealthy leaf. It detects the diseased plant and also gives the preventive measures of the plant. It can save the time of farmers and protect the plants from the disease.

Here we made couple of example disease and few example images during a datasets to spot. In future we can improve the recognition rate of classification process and Further needed to compute amount of disease present on leaf. Then we develop a drone capable of detecting the disease and monitor the field continuously and alert the farmer by sending the SMS so that farmers can take the appropriate actions or we develop a robot that can be trained to detect the disease from the plants and it can be allowed to take appropriate actions.

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