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Detection of Diseases in Flora Through Leaf Image Classification by Convolution Neural Network

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Abstract— The quality of human existence and economic standing are significantly impacted by agriculture. It is the foundation of a nation's economic structure. Therefore, early diagnosis of plant diseases is crucial in both the agricultural sector and in people's daily life. Hunger and starvation are caused by agricultural losses due to plant diseases, especially in less developed nations where access to disease-controlling measures is limited and yearly losses of 30 to 50 percent for main crops are not unusual. Due to inadequate diagnosis of plant diseases, many plants die. Initially, diagnosis of plant disease was performed using MATLAB and machine learning algorithms including SVM. But these diagnoses did not provide accurate results. Also, in previous works website has not been created. To overcome this problem, a CNN model has been proposed that detects plant diseases. This CNN model has been deployed to the website. On this website, the image can be uploaded, and the disease gets predicted according to the image. The detected disease gets displayed on the website. To the CNN model, 15 cases have been fed, including both healthy and unhealthy leaves. The proposed model achieves a greater accuracy of more than 95%. This work offers a major benefit to the farmers by helping them in detecting plant diseases without requiring any special hardware or software.

Keywords- Convolutional Neural Network (CNN); Website; Accuracy; Plant disease detection;

I. INTRODUCTION

The productivity of agriculture is very important to the economy. Plant disease is one of the dangers to agricultural productivity. Appropriate detection of plant diseases can help in the prior identification and cure of those diseased plants. Thus, the proposed model provides a solution by making a proper detection of plant diseases.

Initially, people detected plant diseases manually by looking at the texture of the stems and leaves. But this did not provide accurate results. Later machine learning evolved and MATLAB was used to detect plant diseases. But usage of

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MATLAB requires licensing, which is expensive. After the introduction of Python, its usage in machine learning increased, as Python is more convenient to use. Also, Python is an open-source language, so it does not require licensing like MATLAB. Later SVM algorithm was used for detecting plant diseases. But SVM consumes a lot of time for training the dataset. Also, SVM cannot be used for a larger dataset. Recently, Deep learning is being used, as it provides more accurate results. In this proposed model, Convolutional Neural Network (CNN) has been used, which requires less preprocessing than other algorithms.

In this model, 12 cases of diseased plants are detected. The cases are Bell Pepper Bacterial Spot, Potato Early Blight, Potato Late Blight, Tomato Target Spot, Tomato Mosaic Virus, Tomato Yellow Leaf Curl Virus, Tomato Bacterial Spot, Tomato Early Blight, Tomato Late Blight, Tomato Leaf Mold, Tomato Septoria Leaf Spot, Tomato Spider Mites of three different plants, Bell Pepper Healthy, Potato Healthy, and Tomato Healthy.

II. LITERATURE REVIEW

In this study [1], a CNN-based method for identifying plant diseases is suggested. Based on the temporal complexity and size of the infected region, simulation study and analysis are performed on sample photos. Techniques for image processing are used for this analysis. This model has been fed a total of 15 examples, 12 of which are sick plant leaves. The test's accuracy is 88.80%. The disadvantage of this model is, they have used GUI which is not user-friendly.

In the [2] study, the leaf image was divided into four clusters using k-means segmentation and squared Euclidean distances. The Colour Co-occurrence technique is used for feature extraction. A backpropagation neural network is used to perform the classification.. The overall accuracy is around 93%. This method could achieve greater accuracy as it detects only 5 types of diseases.

Using an artificial neural network (ANN) and other image processing techniques, the [3] research proposes a methodology for early and precise plant disease diagnosis. The suggested model, which has a recognition rate of up to 91%, is built on an ANN classifier for classification and a Gabor filter for feature extraction. The ANN-based classifier combines combinations of textures, colours, and characteristics to categorise various plant diseases and identify them. As a result, this procedure is time-consuming and tedious.

In the [4] paper, the classification of watermelon leaf diseases was done using a neural network-based approach. This classification is based on the RGB colour model's feature extraction of colour information from the recognised pixels. This model's accuracy (75.9%) is way too low.

A web-based tool has been created in the [5] study to identify fruit diseases by uploading photos of the fruit to the system. Parameters including colour, morphology, and CCV (colour coherence vector) are used to extract features. The k-means algorithm has been used to perform clustering. SVM is used to categorize data as infected or uninfected. This research identified pomegranate illness with an accuracy rate of 82%. The disadvantage of this model is, they were only able to detect diseases of pomegranate.

The [6] paper provides a diagnosis procedure that relies mostly on visual cues, exact judgement, and scientific techniques. A picture of a sick leaf is taken. The HSV characteristics are obtained using colour segmentation. The artificial neural network (ANN) is then trained to differentiate between samples with and without illness. This ANN classification offers 80% accuracy, however because it requires a lot of labour, the accuracy is reduced.

In the [7] paper, uses a K-means clustering algorithm with SVM to detect grape plant diseases. The detection rate of the classification process is increased by creating combinations of algorithms employing fusion classification approaches. The accuracy of this model is 88.89%. Here, they were able to achieve this accuracy as they have detected the diseases of grape plants only.

In the [8] paper, uses K-means clustering and Neural network. In this model, the fungal disease of the wheat plant is detected. The accuracy of this model is around 80.2%. Here they have detected the diseases of the wheat plant only.

The [9] publication makes it clear that they employed the CNN model to classify leaf diseases. The CNN model took three matrices representing the R, G, and B channels as input, and the result was fed into the LVQ (Learning Vector Quantization) neural network. 88% accuracy on average was attained. Only the illnesses of the tomato plant have been found here.

In the [10] paper, it was suggested that in order to produce agricultural products, plants must be protected from numerous microorganisms, pests, and bacterial illnesses. These illnesses can spread by looking at the leaves, stems, or fruit. This article discusses the process of converting a picture from RGB (YCbCr) to a different colour space and enhancing it in order to extract leaf feature information for the purpose of early disease detection in plants. With the results of the experiments, the entire system's accuracy was obtained at 90.96%. Here, plant leaf disease is discovered using MATLAB programme. Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc.

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III. INPUT DATA

The dataset for this suggested model was collected from Kaggle, an open-access site. Both healthy and unhealthy plant leaves can be found in the dataset. It can attain greater accuracy because it makes use of a larger dataset.

IV. DATA PRE-PROCESSING

After feeding the dataset as input to the model, the images are pre-processed. Pre-processing involves the conversion of images into an array format, and other techniques such as re-shaping and re-scaling are performed along with Feature extraction. In feature extraction, feature scaling or standardization is performed that helps to normalize the data. This pre-processing helps to identify whether the image is normal or blur. Thus, the clarity of the image is verified in this process.

V. DATA ANALYSIS

Convolutional Neural Network (CNN) model was fed with these pre-processed photos. This CNN model processes an image after receiving it as input. Finally, it provides a classified image as output after recognizing the type of disease. Thus, the predicted disease is obtained as the output.

VI. OUTPUT

The output obtained from the CNN model is deployed to the website. For creating the website HTML, CSS is used for the frontend and Python Flask for the backend. The purpose of HTML is for designing the webpage, and CSS is for styling it. Python Flask helps in connecting the CNN model to the website. The website has a provision to upload an image, and this image is fed to the backend then the output is obtained after the processing of an image.

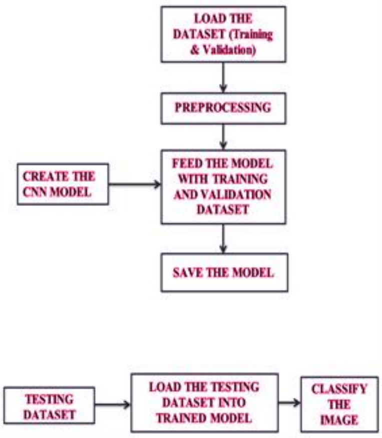

Fig.1 Block diagram for CNN model

Fig 1 explains the procedure followed in the CNN model. In the CNN model, first, the images are loaded from the dataset. For training 80% of the dataset is used. After feeding the training dataset as input to the model, the images are pre-processed. In pre-processing the images are converted into an array format and other techniques such as reshaping and rescaling are performed. Feature extraction is also performed in pre-processing. In feature extraction, feature scaling or standardization is performed which is used to normalize the data. This pre-processing helps to identify whether the image is normal or blur. Thus, the clarity of the image is verified in this process. Following pre-processing, the Convolutional Neural Network (CNN) model receives these pre-processed images. The training and validation dataset are fed to this CNN model, which then processes them. Finally, the model is being saved.

For testing, 20% of the dataset is used. These images are loaded into the trained model. Finally, it provides a classified image as output after recognizing the type of the disease. Thus, the predicted disease is displayed as the output.

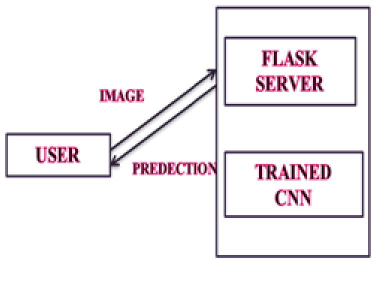

Fig.2 Block diagram for website

Fig 2 explains the framework of this proposed work. According to the framework, the image will be uploaded to **Plant disease prediction** website. The uploaded image is connected to the backend via the Flask server. After being uploaded, the image is trained and predicted using the CNN algorithm.

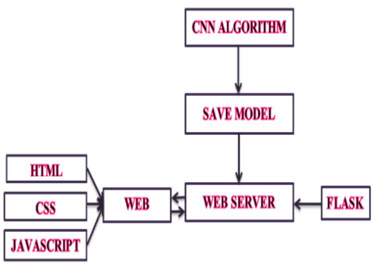

Fig.3 Overall Block diagram

The Fig.3 shows the overall flow of the work. The webpage is created using HTML, CSS, JavaScript, and the webserver is connected using Flask. To this web server, the saved CNN model is applied input.

VII. CNN

For the analysis of visual pictures, a Deep Learning method called a Convolutional Neural Network (ConvNet/CNN) is employed. Comparatively speaking, CNN requires

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substantially less pre-processing than other classification methods.

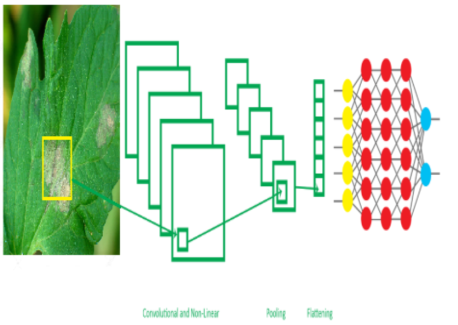

Fig.4 CNN Layers

Among the numerous layers of CNN are:

The first layer in a CNN is called the convolutional layer. The convolution layer is made up of filters that aid in the extraction of specific traits from the input images, producing a feature map. Here is the input-output-based mathematical model.

Inputs:
1) An image matrix (volume) of dimension (h*w*d)
2) A filter (fh*fw*d).

Output:
Output volume of dimension
(h-fh+1)*(w-fw+1)*1

Pooling Layer: The feature maps' size are reduced by using the pooling layer. Therefore, when the photos are too huge, pooling layers would lower the number of parameters. Additionally, it lessens the quantity of computing carried out within the network.

Accepts a volume of size W1×H1×D1

Requires two hyper parameters:
1) Abstraction extent F
2) Stride S

Produces a volume of size W2×H2×D2

Where:
W2= (W1−F)/S+1
H2= (H1−F)/S+1
D2=D1

Max Pooling Layer: The feature map region is where the filter has chosen and concealed the most items.

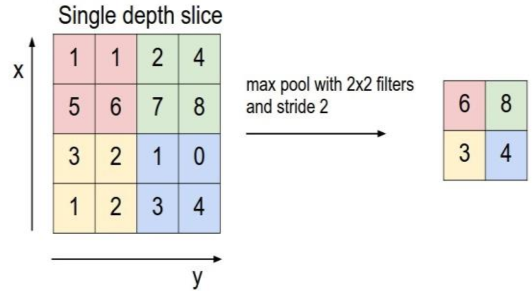

Fig.5 Max Pool Layer

Flattening Layer: This layer reduces the image to a one-dimensional state by creating a single feature vector.

Fully-Connected Layer: Each neuron in the layer with complete connectivity is linked to every activation in the layer below.

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 64, 64, 32)	896
batch_normalization (BatchNo	(None, 64, 64, 32)	128
max_pooling2d (MaxPooling2D)	(None, 32, 32, 32)	0
conv2d_1 (Conv2D)	(None, 32, 32, 64)	18496
dropout (Dropout)	(None, 32, 32, 64)	0
batch_normalization_1 (Batch	(None, 32, 32, 64)	256
max_pooling2d_1 (MaxPooling2	(None, 16, 16, 64)	0
conv2d_2 (Conv2D)	(None, 16, 16, 64)	36928
batch_normalization_2 (Batch	(None, 16, 16, 64)	256
max_pooling2d_2 (MaxPooling2	(None, 8, 8, 64)	0
conv2d_3 (Conv2D)	(None, 8, 8, 128)	73856
dropout_1 (Dropout)	(None, 8, 8, 128)	0
batch_normalization_3 (Batch	(None, 8, 8, 128)	512
max_pooling2d_3 (MaxPooling2	(None, 4, 4, 128)	0
conv2d_4 (Conv2D)	(None, 4, 4, 256)	295168
dropout_2 (Dropout)	(None, 4, 4, 256)	0
batch_normalization_4 (Batch	(None, 4, 4, 256)	1024
max_pooling2d_4 (MaxPooling2	(None, 2, 2, 256)	0
flatten (Flatten)	(None, 1024)	0
dense (Dense)	(None, 128)	131200
dropout_3 (Dropout)	(None, 128)	0
dense_1 (Dense)	(None, 1)	129

Total params: 558,849
Trainable params: 557,761
Non-trainable params: 1,088

Fig.6 Model Summary

VIII. RESULTS AND DISCUSSION

The Plant Disease Prediction (Fig. 7) is the website which helps to detect the plant disease. The image of diseased plant leaf is uploaded in the website.

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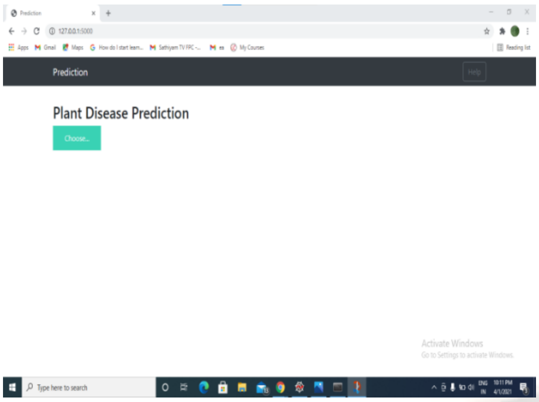

Fig.7 Home Page

- The "**choose**" button is available on the website to select the image. After selecting the image, the corresponding image gets displayed on the website. Along with the image, a "**predict**" button also appears on the website.

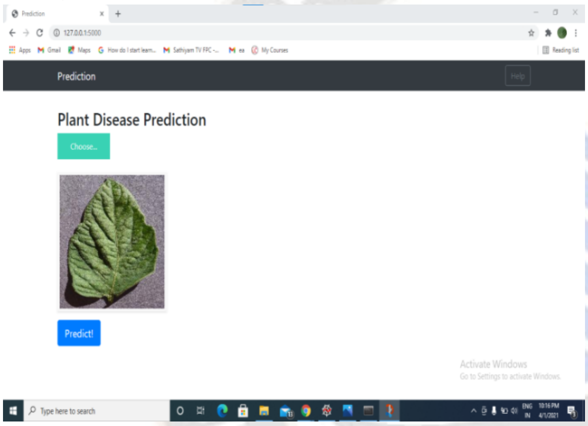

Fig.8 Uploading the Image

On clicking the predict button, the disease gets predicted according to the image uploaded. After this, the predicted result is displayed on the website below the image. If the result is a diseased plant leaf, then the remedy is also displayed accordingly.

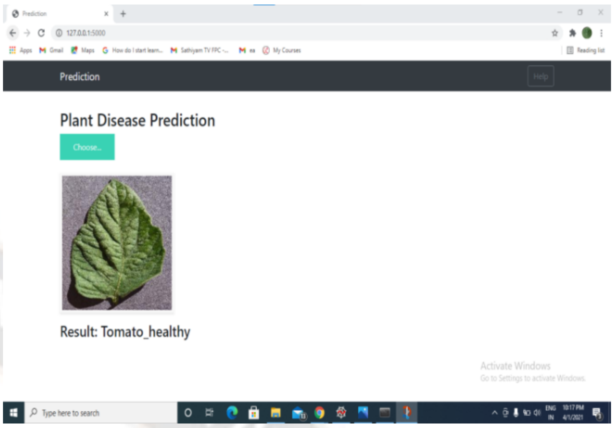

Fig.9 Predicting the disease and displaying the result

An accuracy of 99% is obtained as shown in the Fig 10.

```
print("\n\tPERFORMANCE METRICS\n\t****************************\n")

final_loss, final_accuracy = model.evaluate(X_val, Y_val)
print('Final Loss: {}, Final Accuracy: {}'.format(final_loss, final_accuracy))


        PERFORMANCE METRICS
        ****************************

130/130 [==============================] - 2s 17ms/step - loss: 0.0301 - accuracy: 0.9906
Final Loss: 0.030051104724407196, Final Accuracy: 0.9905568957328796
```

Fig.10 Accuracy Estimation

Ref.No	Algorithm	Pros	Cons
1.	CNN	12 type of plant diseases are detected	• The accuracy is only around 88% • This work has not included website
2.	K-means clustering	An accuracy of 93% is achieved	• Only 5 types of diseases were detected • Website has not been created • The accuracy is relatively less as it detects only 5 types of diseases
3.	ANN	An accuracy of 91% is achieved	• ANN method is tedious and time consuming • Website has not been created
4.	Neural networks	Many diseases of watermelon are detected using RGB color model	• An accuracy of only 75.9% is achieved • This work did not use a website • Diseases of only watermelon plant are detected
5.	SVM	An accuracy of 82% is obtained	• This work did not use a website • Diseases of only pomegranate plant are detected • The accuracy is less for detecting only one type of plant disease

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6.	ANN	An accuracy of around 80% is achieved	• ANN method is tedious and time consuming • The accuracy is less • 3) Website has not been created
7.	SVM algorithm.	An accuracy of 88.89% is achieved	• Diseases of only grape plant are detected • The accuracy is less for detecting only one type of plant disease • Website has not been created
8.	K-means clustering and Neural network	An accuracy of around 80.2% is obtained	• Diseases of only wheat plant are detected • The accuracy is less for detecting only one type of plant disease • Website has not been created
9.	Classification Based on CNN with LVQ Algorithm	Average accuracy of around 88 percent was achieved	• Diseases of only tomato plant are detected • The accuracy is less for detecting only one type of plant disease • Website has not been created
10.	Image processing using MATLAB	An accuracy of around 90.96% is achieved	• Usage of MATLAB requires licensing • Website has not been created

Table 1. Analysis of the Techniques

X. CONCLUSION

The proposed model is implemented using the CNN algorithm. As the CNN algorithm is used, greater accuracy of 99% is achieved. Also, a website has been created to deploy the CNN model. Usage of the website does not require any additional software or hardware. Thus, plant diseases are detected in a user-friendly way. In addition to detecting diseases, a remedy is also provided. This remedy would help the farmers in curing plant diseases. Thus, the proposed work will save time and money for farmers. Farmers are the assets of the nation. By helping them, the wealth of the nation rises. As a result, this work contributes to the economy. Further, this work can be extended by including a larger dataset that contains different types of plants.Also, a responsive website that is compatible with mobiles and i-Pads can be created.

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