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PLANT DISEASE DETECTION USING DEEP CONVOLUTIONAL NEURAL NETWORKS

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ABSTRACT:

Nowadays plant disease is becoming more and more serious in the agriculture, farmers suffer a lot due to the infection, drastic climate changes and lack of immunity in crops and their yield is also affected due to the lack of detection. This causes large scale demolition of crops, decreases cultivation and eventually leads to financial loss of farmers. Due to rapid growth in variety of diseases and adequate knowledge of farmer, identification and treatment of the disease has become a major challenge. The leaves have texture and visual similarities which attributes for identification of disease type.

Hence, computer vision employed with deep learning which provides the way to solve this problem. This paper proposes a deep learning-based CNN model which is trained using plant village dataset containing various images of healthy and diseased leaves. The performance of the proposed model is compared with the existing model and result is presented in the section.

KEY WORDS:

Deep learning, Disease detection, Artificial Neural Network, Convolution Neural Network.

I. INTRODUCTION

Deep Learning can play a vital role to detect and classify the plant diseases and it helps the famer to identify the diseases and they can take necessary action to control it. The basic idea of deep learning is: using neural network for data analysis and feature learning, data features are extracted by multiple hidden layers, each hidden layer can be regarded as a perceptron, the perceptron is used to extract low-level features, and then combine low-level features to obtain abstract high-level features, which can significantly alleviate the problem of local minimum. Deep learning overcomes the disadvantage that traditional algorithms rely on artificially designed features and has attracted more and more researchers" attention. It has now been successfully applied in computer vision, pattern recognition, speech recognition, and natural language processing and recommendation systems.

Deep learning techniques used to detect plant diseases are more accurate and less time consuming compared to the traditional Image processing techniques.

II. SURVEY ON PLANT DISEASE DETECTION USING DEEP LEARNING:

Olaf Ronneberger et al… [1] have done Image segmentation on biomedical images dataset. They have done segmentation of neural structures found in microscopic images of human blood samples. Cell growth tracking in a human body is performed automatically using this approach. The typical task of CNN is classification, where output to single image is a class label. But in many other applications, localization information should be included in output. That is each pixel in an image need to be assigned to a class label. In their work they have used CNN to segment the image to identify different cell types and to track the growth of some specific cells in the body over a period of time. Along with identifying the cells in the body, the location of those cells is also important to monitor the cell growth properly. They have applied segmentation task on a raw image which classify objects with different colors then a black & white segmentation mask is generated using white for foreground and black for background. Then the image is mapped with pixel wise loss weight to identify the border pixels. So,

for that reason ceresin et al predicted the class label of pixels in images by providing a region which is local to the pixel in that image and with the help of a sliding window setup to train the network. Accuracy is 77.5%, training time is 10 hours.

Sachin D. Khirade& et al… [2] Identification of the plant diseases is the key to preventing the losses in the yield and quantity of the agricultural product. It requires tremendous amount of work, expertize in the plant diseases, and also require the excessive processing time. Hence, image processing is used for the detection of plant diseases. Disease detection involves the steps like image acquisition, image pre-processing, image segmentation, feature extraction and classification. This paper discussed the methods used for the detection of plant diseases using their leaves images. This paper discussed various techniques to segment the disease part of the plant. This paper also discussed some Feature extraction and classification techniques to extract the features of infected leaf and the classification of plant diseases. The accurately detection and classification of the plant disease is very important for the successful cultivation of crop and this can be done using image processing. This paper discussed various techniques to segment the disease part of the plant. This paper also discussed some Feature extraction and classification techniques to extract the features of infected leaf and the classification of plant diseases. The use of ANN methods for classification of disease in plants such as self-organizing feature map, back propagation algorithm, SVMs etc. can be efficiently used. From these methods, we can accurately identify and classify various plant diseases using image processing technique.

Prof. Sanjay, B. Dhaygude& et al… [3] The application of texture statistics for detecting the plant leaf disease has been explained Firstly by color transformation structure RGB is converted into HSV space because HSV is a good color descriptor. Masking and removing of green pixels with pre- computed threshold level. Then in the next step segmentation is performed using 32X32 patch size and obtained useful segments. These segments are used for texture analysis by color co-occurrence matrix. Finally if texture parameters are compared to texture parameters of normal leaf.

Amandeep Singh, ManinderLal Singh& et al… [4] The most significant challenge faced during the work was capturing the quality images with maximum detail of the leaf color. It is very typical task to get the image with all the details within a procurable memory. Such images are formed a through high-resolution and thus are of 6-10MB of size. This was handled by using a Nikon made D5200 camera which served the task very well. Second challenge faced was to get rid of illumination conditions as from the start to the end of paddy crop season; illumination varies a lot even when the image acquiring time is fixed. However the solution to this is variable user defined thresholding and making necessary adjustments to the shades of LCC.

M.Malathi, K.Aruli& et al… [5] They provide survey on plant leaf disease detection using image processing techniques. Disease in crops causes significant reduction in quantity and quality of the agricultural product. Identification of symptoms of disease by naked eye is difficult for farmer. Crop protection especially in large farms is

done by using computerized image processing technique
that can detect diseased leaf using color information of leaves. Depending on the applications, many image processing technique has been introduced to solve the problems by pattern recognition and some automatic classification tools. In the next section this papers present a survey of those proposed systems in meaningful way.

MalvikaRanjan, Manasi Rajiv Weginwar& et al… [6] Describes a diagnosis process that is mostly visual and requires precise judgment and also scientific methods. Image of diseased leaf is captured .As the result of segmentation Color HSV features are extracted. Artificial neural network (ANN) is then trained to distinguish the healthy and diseased samples. ANN classification performance is 80% better in accuracy.

Y.Sanjana, AshwathSivasamy& et al… [7] In this it describes the uploaded pictures captured by the mobile phones are processed in the remote server and presented to an expert group for their opinion. Computer vision techniques are used for detection of affected spots from the image and their classification. A simple color difference based approach is followed for segmentation of thedisease affected lesions. The system allows the expert to evaluate the analysis results and provide feedbacks to the famers through a notification to their mobile phones. The goal of this research is to develop an image recognition system that can recognize crop diseases. Image processing starts with the digitized color image of disease leaf. A method of mathematics morphology is used to segment these images. Then texture, shape and color features of color image of disease spot on leaf were extracted, and a classification method was used to discriminate between the three types of diseases.

Dan C. Cirean et al. [8] It have segmented neuronal structures in the stacks of electron microscopy images. The label of each pixel in the image is predicted by the pixel centered at square window in which the pixel exists. Then the input layer maps each pixel to a neuron. Then convolution and max pooling layers are applied to preserve the 2D information and to extract features of the image. This approach outperforms the competing techniques with a large margin in all three categories. The solution is based on DNN (Deep neural network) used as a pixel classifier. The probability of a pixel being a membrane is calculated.

BhumikaS.Prajapati, VipulK.Dabhi& et al… [9] In this detection and classification of cotton leaf disease using image processing and machine learning techniques was carried out. Also the survey on background removal and segmentation techniques was discussed. Through this survey, we concluded that for background removal color space conversion from RGB to HSV is useful. We also found that thresholding technique gives good result compared to other background removal techniques. We performed color segmentation by masking green pixels in the background removed image and then applying thresholding on the obtained masked image to get binary image. This is useful to extract accurate features of disease. We found that SVM gives good results, in terms of accuracy, for classification of diseases. There are five major steps inour proposed work, out of which three steps have been implemented: Image Acquisition, Image pre-processing, and Image segmentation.

Venugopal K.R. et al. [10] It have combined CNN with CC (connected component) algorithm to segment the SEM images. As we know CNN is used to extract features directly from raw images with minimal pre-processing. Also, CNN is able to recognize patterns in the image which have not even provided as training data before. Provided it resembles one of the training data images. Accuracy (F-score) of the model is found to be 78% [10]. They have done detection of neuron tissues in done on SEM (scanning images microscopy) dataset. SEM provides dataset of images whose resolution is almost perfect to identify the components in dense neuropil. In this approach all steps of parameter tuning is automated. So, in order to do automate and avoid human interaction in parameter tuning CNN has been introduced. Only CNN has the capability to identify features that has not even been introduced earlier, although it must resemble one of the training input samples. They have represented the CNN with the help of a directed graph where pixels are belonging to nodes and filters or kernels belong to the edges. In order to recognize 2D patterns with very high degree of images transformations techniques a CNN is used as a multi-layer perceptron. All the filters in the CNN are given a size of 5 * 5. [10]. Random selection on the basis of normal distribution of standard deviations is one to calculate the weights of the edges in the model. The input to the CNN is a raw EM image. Detection of features in the image is done automatically by the CNN. CNN automatically learns by adjusting its weights using stochastic gradient descent learning algorithm.

III. PLANT DISEASES AND ITS SYMPTOMS:

Following are the some basic information on bacterial, viral, fungal diseases.

Bacterial diseases: bacterial diseases named as bacteria causes different kinds of symptoms that include overgrowths of plants, leaf spots, scabs and cankers. Bacterial infection symptoms are nearly about similar like fungal disease. The most Common type of symptoms found in bacterial disease is leaf spot, viral diseases: In the case of viral diseases it is little hard to identify and analyze. Symptoms of viral disease are Mosaic leaf pattern, Crinkled leaves, Yellowed leaves, Plant stunting. Some of the major viral disease are Tobacco mosaic and Tomato spotted virus, Potato virus, Cauliflower mosaic virus etc.. Fungal diseases: these are the diseases which are commonly found on wide range of vegetables. Fungal diseases are responsible for an enormous damage on plant. Some of major fungal diseases are

IV. COMPARATIVE ANALYSIS:

Anthracnose, Downy mildews, Powdery mildews, Rusts, Rhizoctonia rots, Sclerotinia rots, Sclerotium rots.

Bacterial diseases

Fig 1.

Viral diseases

Fig 2.

Fungal diseases

Fig 3.

Authors	Year	Dataset				Model	Accuracy
		Name of Crop	Data set name	No.of Classes	No.of Images		
Davinder Singh	2020	13 speices	Plant village	27	2598	MobileNet ,R-CNN	70.53%
J.S.H. Al-bayati et al	2020	Apple	Plant village	6	2539	DNN, SURF, GOA	98.28%
AndrasAnderla et al.,	2019	12 crop species	Plant Disease	42	79265	GAN architecture	93.67%
Peng Jiang	2019	Apple	Real World(ALDD)	5	26377	INAR-SSD	78.80%
Andre Abade et al.,	2019	14 crop species	Plant village	38	54000	Mutichannel CNN	99.59%
RishabhYadav et al.	2019	7 crop species	Plant village	23	8750	Mutichannel CNN	97.39%
Geetharamani et al.,	2019	14 crop species14 crop species	Leaf disease dataset	39	61486	9-layer deep CNN	96.46%
Sijiang Huang et al.,	2019	8 crop species	Plant Disease	19	40000	U-Net, Two-head network using pretrained model	98.07% 87.45%
Joana Costa et al.,	2019	Apple, Peach, Tomato	Plant village	16	24000	InceptionV3 CNN using hierarchical approach	97.74%

Robert Luna et al.,	2018	Tomato	Own	4	4923	Faster R-CNN, CNN	91.67%
Edna Too et al.,	2017	14 crop species	Plant village	38	54000	DenseNets	99.75%

V. METHODOLOGY

This resolves the problems which were discovered from the case study made by providing an approach which works as follows: Data regarding the plant disease were fetched through an application and processed to remove null values and unwanted values. Finally the important features are selected and visualized to the users through necessary precautions and remedies.

The following are methods:

A. CONVOLUTION NEURAL NETWORK (CNN)

Convolution Neural Networks (CNNs) are used to detect the disease in plant's leaves. CNN is an evolution of simple ANN that gives better result on images. Because images contain repeating patterns of particular thing (any image). Two important functions of CNN are convolution and pooling. Convolution is used to detect edges of patterns in an image and pooling is used to reduce the size of an image. Moreover training of these models are done using Jupyter notebook and Keras API of Tensorflow. Keras is tensor flow's high level API for building and training deep learning models. A CNN consists of an input layer, multiple hidden layers and an output layer. In hidden layer consist of Convolution layer, Rectified Linear Unit, pooling layer and fully connected layer. The CNN architecture for the proposed model is shown in fig 4. The input layer takes the resized, gray scaled image and output layer produces the detection of the disease and provides remedies. The detailed explanation of the remaining layers as fallows,

1. Convolutional Layer

The training data (images of the diseased and healthy rice plant) was sent to input layer of CNN. The convolution operation is then performed on input samples; the input is convolved with filters called kernels, that is, a number of filters slide over the feature map of the previous layer, to produce output feature maps.

2. Rectified Linear Unit (ReLu)

In this layer is usually called as activation function layer, ReLu is one of the activation function. There are various types of activation function available such as sigmoid, Tanh, ReLU, Softmax, etc. In our model ReLu activation function is used in hidden layers. It is the most widely used activation function. In ReLu layer the image with negative pixel values are replaced with pixel value 0 and remaining pixel retain as it is. The ReLU function can be written in the mathematical form in equation 1,

$$f(x)=\{\ 0 \text{ if } x<0,\ x \text{ if } x>=0$$

Where, x is a pixel value

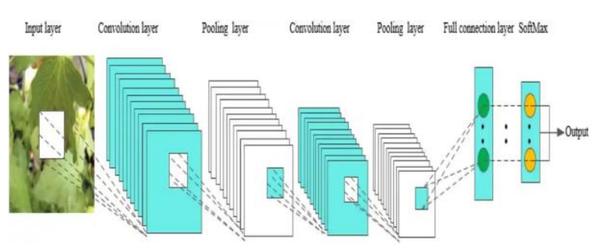


Fig 4. Convolutional Neural Network

3. Pooling Layer

A pooling layer performs reduction operation along the dimensions of image (Width, Height), resulting dimensionality reduction. The primary aim of pooling operation is to reduce the size of the images as much as possible. This scans across the image using a window and compresses the image extracting features. Average pooling and Max pooling are the most commonly used methods in pooling layers. In max pooling largest value of the pixel is taken from the selected window of the image, while average pooling takes the average of all pixel values within the window.

4. Flattening

We flatten our entire matrix into a vector like a vertical one. So, that it will be passed to the input layer.

5. Fully Connected Layer

After the convolution + RELU+ Pooling layers, we stack up these layers many times until the image is reduced to a vector. In this layer actual classification will going to happen. In this layer all the neurons are interconnected; this layer produces an N-dimensional vector, where every neuron in this layer contains the vectors of the features extracted from the image. The proposed system has concentrated on detecting the diseases and provides the suitable remedies, thus leads to increase in crop production. In this system it detects the most common and frequently occurring diseases and provides pesticides or insecticides as a remedy to control the disease. Thus the disease is detected by CNN algorithm.

B. DATA SET- [PLANT VILLAGE DATASET]

The Plant Village dataset consists of 54,303 healthy and unhealthy leaf images divided into 38 categories by species and disease and it is also openly available on internet. Description of these classes and dataset is given in following Table- I

Table-1:Dataset

Class	Plant Name	Healthy or Diseased	Disease Name	Images (Number)
C_0	Apple	Diseased	Apple_scab	2016
C_1	Apple	Diseased	Black_rot	1987
C_2	Apple	Diseased	Cedar_apple_rust	1760
C_3	Apple	Healthy	-	2008
C_4	Blueberry	Diseased	-	1816
C_5	Cherry_(including_sour)	Diseased	Powdery_mildew	1683
C_6	Cherry_(including_sour)	Healthy	-	1826
C_7	Corn_(maize)	Diseased	Cercospora_leaf_spotGray_leaf_spot	1642
C_8	Corn_(maize)	Diseased	Common_rust	1907
C_9	Corn_(maize)	Diseased	Northern_Leaf_Blight	1908
C_10	Corn_(maize)	Healthy	-	1859
C_11	Grape	Diseased	Black_rot	1888
C_12	Grape	Diseased	Esca_(Black_Measles)	1920
C_13	Grape	Diseased	Leaf_blight (Isariopsis_Leaf_Spot)	1722
C_14	Grape	Healthy	-	1692
C_15	Orange	Diseased	Haunglongbing (Citrus_greening)	2010
C_16	Peach	Diseased	Bacterial_spot	1838

C_17	Peach	Healthy	-	1728
C_18	Pepper_bell	Diseased	Bacterial_spot	1913
C_19	Pepper_bell	Healthy	-	1988
C_20	Potato	Diseased	Early_blight	1939
C_21	Potato	Diseased	Late_blight	1939
C_22	Potato	Healthy	-	1824
C_23	Raspberry	Healthy	-	1781
C_24	Soybean	Healthy	-	2022
C_25	Squash	Diseased	Powdery_mildew	1736
C_26	Strawberry	Diseased	Leaf_scorch	1774
C_27	Strawberry	Healthy	-	1824
C_28	Tomato	Diseased	Bacterial_spot	1702

Fig. 5: Sample of Images from Plant Village Dataset

In this table numbers of images are available in each class. Each class contains approximately 2000 images. Fourteen different plants are available in this dataset. For every plant healthy as well as diseased images of leaves are available. Most of the images belong to Tomato and Apple plants. Least images are from Raspberry, Soybean, and Squash class. Below image show some images of different leaves which are available in dataset. Dataset is divided into two parts one for training and other for Testing. Splitting of dataset is 80/20 ratio randomly. 80% for the training dataset and rest 20% for testing dataset. Training dataset consists 56,236 images and testing consists 14,059 images. Training of model is done using 56,236 images and 14,056 images were kept unseen by model so that accuracy of model can be checked.

C. MODEL DESCRIPPTION

First some preprocessing is applied on dataset in form of augmentation to increase size of dataset in order to achieve better accuracy. Then images size is reduced by 256x256 pixels. After that a convolution neural network based model will be created with multiple pooling and convolution layers and a dense layer for prediction. Five convolution layers with 3x3 filters are used and five MaxPooling2D layers with 2x2 filter.

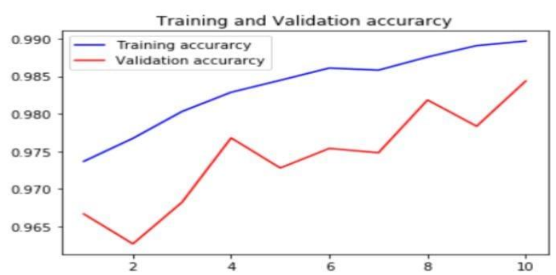
Batch normalization is used to scale data on particular scale but the difference is that it not just does it on input layer but it also does it at other hidden layers. At last model is trained on plant Village dataset.

VI. RESULT AND DISCUSSION

Plant Village dataset were used to test the accuracy of this model. These images are from 38 different classes. 20% of each class randomly selected for testing. Testing dataset gives accuracy more than 98%. It means 1379 images from 14,059 images were classified correctly by model. Below is the Training and Validation accuracy graph generated by our model on testing dataset.

1. Accuracy Graph Plot

This graph represents the change in models prediction accuracy using test set and validation set with the increase in number of epochs done while training the model



No. of Epochs

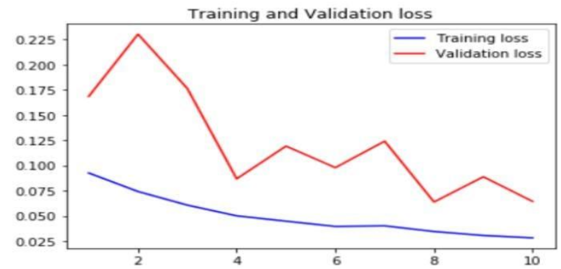
Fig 6. Training vs. Validation Accuracy

Here, we can see how training and validation accuracy is increasing with the increase in number of epochs. With each epochs there is a small improvement happening in the accuracy.

2. Loss Graph Plot

This graph represents the change in the

value of training loss using test set and validation set data with the increase in number of epochs.



No. of Epochs

Fig 7. Training vs. Validation loss

Here, we can see how the validation loss and training loss reaches to zero with the increase in the value of number of epochs.

Table-II: Image Classes with Better Accuracy

Class	Total	Correct Classified	Mis-classified
Corn_(maize)___healthy	186	186	0
Tomato___Tomato_mosaic_virus	179	176	3
Strawberry___healthy	182	175	7
Corn_(maize)___Common_rust_	191	188	3
Corn_(maize)___Northern_Leaf_Blight	191	175	16

Table- III: Performance of the model

Model	Dataset for Training	Dataset for Testing	Training Accuracy	Testing Accuracy
CNN	PlantVillage (80%)	PlantVillage (20%)	99%	98%+
CNN	PlantVillage (80%)	Actual Environment (100 Images)	99%	95%+

VII. CONCLUSION

In this project, a new approach of using deep learning method was Explored in order to automatically classify and detect plant diseases from leaf Images. The developed model was able to detect leaf presence and distinguish between healthy and unhealthy leaves of different diseases, which can be Visually diagnosed. We studied and analyzed the datasets and identified the Difference between the infected and non-infected region of the plant leaves.

The Complete procedure was described, respectively, from collecting the images From dataset and used for training and validation to image pre-processing and Augmentation and finally the procedure of training the deep CNN. And in this Work, we also discovered several remedies for the affected plants. The result Can be shown using the interface and several remedies can be given to the Farmers to enhance their farming fields.

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