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Plant Disease Classification using Convolution Neural Network

Ganipisetty Akhil Bhargav[1], Dr. Ajita Pathak[2]
Amity University, Lucknow, India

Abstract: Today, agriculture is back bone of our country's economy. Agriculture is sometimes referred to as the art and science of raising crops and feeding domestic animals. Moreover, half of the country's GDP is contributed by the agricultural sector. The pace of output is influenced by the crops, fertilisers, and cultivation techniques. Unknown plant or crop diseases now have a significant impact on agricultural productivity. It may be difficult for a farmer to spot a plant disease, but it may also be difficult to do so without a microscope or even with our unaided eyes. To address this complex problem, we thus provide a methodology that uses machine learning and deep learning to identify the plant sickness. Convolution neural networks can be used in conjunction with deep learning and machine learning to identify plant diseases. Deep learning allows us to characterise the behaviour and symptoms of the plant in addition to detecting sickness. By employing various architectures, deep learning aids in the visualisation of the picture. There are several types of architecture, including AlexNet, VGG, ResNet, and CNN, among others. We have developed a model to identify plant diseases using the proper architecture. Finally, this work analyses and makes predictions on how image processing-based plant disease and pest detection may progress in the future.
Keywords: Plant disease detection, CNN, neural network, deep learning, machine learning, etc.

I. INTRODUCTION

In general, agriculture and farming are important to the nation's economy and way of life. Some newly discovered plant diseases are having an impact on our economy, ecology, and even our health. Plants are essential for lowering greenhouse gas emissions and combating global warming. Numerous studies have shown that plants have a substantial impact on human eating habits as well as climate change. We are unable to even begin to count the number of illnesses. Plants make up most of the food we consume, thus it is critical for them to remain robust and healthy. We have thus proposed a solution to protect our plants against fatal diseases. Like humans, plants are susceptible to a variety of diseases that result in loss of food, money, and way of life for common people. The number of ailments is too great for us to even begin to list them.

There are billions of plant diseases that can shorten a plant's life, including apple scab, black rot, common rust on corn, white mould, and 'Corn(maize)Northern Leaf Blight', 'Grape Black rot', 'Grape Esca (Black Measles)', 'Grape healthy', 'Grape Leaf blight (Siriasis Leaf Spot)', 'Orange Hangdogging (Citrus greening)', 'Peach Bacterial spot', 'Peach healthy', ' We cannot diagnose these disorders with our unaided sight or through microscopic analysis. Particularly at this time, technology has drastically altered our way of life. There are several approaches to taking to discover the plant illness. We are unable to identify some of these abnormalities either through microscopic examination or with unassisted vision. Technology has greatly changed our way of life, especially at this time. There are several methods you may use to identify the plant disease. In the realm of machine learning, the conventional method of utility has already been suggested by several scholars. The primary application of the methodology used is to use deep learning and discover plant diseases. In comparison to the more conventional machine learning approach, the key benefit of deep learning is automation. Plant's pictures are suggested to be used to identify the illness, as done by researchers in past [1]. The automated computer vision system is used, which provides us the suitable results in the prediction to detect the of plant disease. Convolution neural networks (12) are used to implement the deep learning approach. Numerous machine learning theories have been put out for the diagnosis of plant diseases, however deep learning, a subset of machine learning, provides us with greater accuracy than machine learning. There are several aspects connected to CNN that allow us to extract features from pictures, including RGB values, vertical and horizontal borders, etc. To train the given neural network to predict plant diseases, several photos of healthy and ill plants can be provided. Plant disease detection uses the advantage of the automated computer vision system, which offers us adequate outcomes in the forecast. The deep learning technique is implemented using convolution neural networks. We can extract features from images using a number of CNN-related factors, such as RGB values, vertical and horizontal boundaries, etc. Convolution neural network is the most efficient deep learning technique for obtaining visual characteristics.

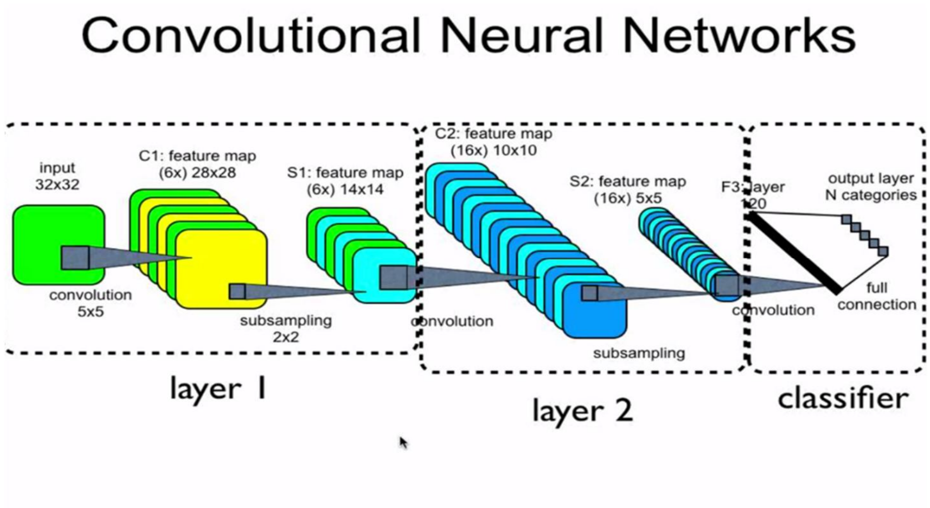

Fig1. Working of CNN for Plant Disease Detection classification

II. LITERATURE REVIEW

According to Khirade et al. [1] it is mentioned basically implemented the plant disease detection by the usage of image processing and this method is generally uses a technique of the visualising the plant leaf by using the patterns which are visible on the plant. This method is preferable but according to the implementation part of the image processing It is difficult to implement by using image processing techniques. The main disadvantage of the image processing is consuming more time to predict the certain disease of the plant and it is even costlier according to the quantity of the detectors used to identify the disease in a plant. It has complexity to implement because it has lot of steps to take into consideration while implementation of the plant disease detection.

According to Ujwalla Gawande et al. [2] uses the plant disease detection by image processing techniques, this paper utilises the various techniques of the image processing in the detection of the plant, formally it is a best approach of detecting the disease, by using the techniques of the image processing author is finding the various disease such as viral disease, Fungal diseases and Bacterial kind of diseases etc. As we mentioned in the literature review of the [1] image processing techniques has time consuming and relatively it plays an important role in the identification of disease in this paper also and Image processing have lot of techniques to analyse the image.

According to Front.Plant Sci et al. [3] Generally uses the traditional methods of the Deep Learning such as ALEXNET and GOOGLENET. These methods are usually designed to visualization in the large-scale recognition. AlexNet uses the technique of the LeNet5 architecture which was discovered in the year of the 1990’s, it is the best technique to use and it utilises some time to predict the disease and deep learning is one of the best developed technique to predict the disease and it is also a sub branch of the machine learning field.

According to Jose R.C. Piqueira et al. [4] suggested to develop a new multimodal logistic regression-based picture identification system. There are several advancements, especially in picture separation and identification systems. An enhanced entropy extraction approach for picture classification that can precisely and dynamically compute limit is provided. To increase the accuracy and intelligence of this technology, real colour image processing and the regional growth approach are coupled. Multiple linear regression and picture extraction of features are used to create the identification system. After comparing the outcomes of several picture training libraries, it was determined that the technology has strong image processing capabilities, as well as high accuracy and dependability.

According to JinChang ren et al. [5] deals with the first step in effectively and accurately preventing diseases in plants in a complex environment is to identify the invasive plants. The with quick advancement of precision agriculture, plants detection of disease becomes digitalized and data-driven, enabling sophisticated information for decision - making, clever analysis, and long-term planning. This study suggests a deep learning-based mathematical model for identifying and detecting plant diseases that enhances generality, accuracy, and training effectiveness. Initially, to identify and locate the leaves in a complicated environment, the region proposal network (RPN) is used. Then, using the Chan-Vese (CV) method, pictures that have been segmented based on the output of the RPN algorithm contain the characteristic of symptoms. The segmented leaves are then added to the transfer learning model, which was trained using the dataset of ill leaves under basic foundation.

According to Ashwini C et al. [6] authors proposed the current method employed by farmers for detection of plant diseases allows them to recognise the illnesses with the human eye and the understanding of plant disease. It takes a lot of time, is tough, and requires poor precision to perform this with a lot of plants. It costs a lot to consult specialists. In these situations, proposed solutions are put into practise, using technologies for the automated diagnosis of illnesses that reduce costs and make your procedure more useful and enhance the accuracy. When diagnosing a disease in plants, it is possible to add a high degree of intricacy by visually studying the indications just on plant's leaves., in et al. [7] the authors consider the municipality refers to a worldwide concept that combines ai technology, big data, decision-making, information and communication technology (ICT), and the Internet of Things in order to advance environmental sustainability (IOT). These processes are linked together to address problems in daily living. One of a person's essential necessities was food. The the world's population is growing every day. Therefore, it is crucial to raise enough food to feed a such large population. However, as time goes on, different plant diseases afflict them, which has a negative impact on agricultural plant productivity. Aside from the fact that the economies of many nations are heavily reliant on the production production, a nation must also achieve agricultural output of essential farm commodities for its citizens.

According to Srdjan Sladojevic et al. [8] discuss about the domain of image categorization, the most recent convolutional neural networks (CNNs) have shown excellent results. In this article, a novel method for classifying leaf images using deep convolutional networks is used to construct a model for plant disease identification. Innovative training methods and the method employed make it simple and quick to apply the system in real-world settings. With the capacity to differentiate between plant leaves and their surrounds, the created model can identify 13 distinct forms of plant illnesses from leaf samples. This approach to identifying plant diseases has, as far as we know, never been put out before. The whole process of putting this disease identification model into practise, from obtaining photos to building a database that has been approved by agriculture specialists, is comprehensively documented all through the publication. The deep Network instruction was carried out using Caffe, a supervised neural serve as a platform by Berkley Vision and Learning Centre. For independent class tests, the experimental results using the constructed model had an average accuracy of 96.3%, ranging from 91% to 98%.

According to Tonmoy Hossain et al. [9] Convolutional Neural Networks (CNN) are a crucial machine learning technology for medical picture segmentation and classification. Deep learning plays a significant role in medical automation. To test the suggested classifier, two data sets were created. True positive and true negative are terms used to denote the proper categorization of abnormalities and the normal picture, respectively. The accuracy with which the classifier distinguished between the healthy and ill states serves as a measure of its capacity. The suggested classifier is 90% accurate for data set DS1 and 100% accurate for data set DS2, respectively.

According to Pranay Patel et al. [10] Deep learning is a relatively new, cutting-edge method for analysing images and producing reliable results. For the identification and categorization of leaf diseases, a variety of deep learning and image processing approaches are applied. For disease identification, deep learning methods including CNN, Fast RCNN, Faster RCNN, and Mask RCNN as well as image analysis methods like image pre - processing, segmentation, extraction of features, etc. are employed. According to the report, techniques for image processing are less accurate than deep learning techniques. There are several uses for plant leaf disease detection in domains like physiological studies and agricultural institutes. Agriculture productivity is an important factor in economic growth. This article provides a comprehensive overview of the numerous methods used to identify plant leaf diseases. It also includes an overview of several disease categorization methods that may be applied to the identification of plant disease identification. Several writers have described how to identify leaf diseases using various techniques and have provided recommendations for various kinds of implementation.

According to Jun Liu et al. [11] The productivity and quality of plants are greatly influenced by plant pests and diseases. The detection of plant diseases and pests may be done via image processing. Deep learning has performed better conventional approaches in the field of digital image processing in recent years. Researchers' top research concerns now centre on how to identify plant diseases and pests using deep learning technologies. This paper defines the difficulty with detecting plant diseases and pests and makes a comparative to conventional techniques for doing so.

According to Punam Bedi et al. [12] proposes a new way to identify the One of the trickiest issues in agriculture is the early diagnosis of plant diseases. The entire output may be negatively impacted by infections if they are not discovered early on, which would lower farmers' profitability. Numerous researchers have developed various cutting-edge solutions based on Deep Learning and Machine Learning techniques to address this issue. Unfortunately, the majority of these algorithms either have low classifier performance rates or utilise millions of training parameters. In order to identify plant diseases automatically, this research suggests an unique hybrid model based on Convolutional Autoencoder (CAE) networks and Convolutional Neural Networks (CNN).

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According to Muhammad Hammad Saleem et al. [13] Plant pathogens have an impact on the development of their particular species, hence early detection is crucial. Numerous Machine Learning (ML) models have been used for the identification and classification of plant diseases, but with the development of Deep Learning (DL), a subset of ML, this field of study now looks to have significant potential for improved reliability. In order to identify and categorise the signs of crop diseases, several developed/modified DL architectures are used in conjunction with such a number of visualisation approaches. Additionally, a variety of performance indicators are employed to assess these structures and methodologies.
According to Med Brahimi, et al. [14] discusses about the Several scientists have recently attempted to enhance the effectiveness of systems that identify plant diseases by drawing inspiration from the success of deep learning in computer vision. Sadly, most of this research were based mostly on AlexNet, GoogleNet, or other comparable designs and did not make use of the most current deep architectures. Additionally, because deep learning visualisation techniques are not used, these deep classifiers are opaque and are referred to as "black boxes." In this chapter, we examined various cutting-edge Convolutional Neural Network (CNN) designs utilising three learning techniques on a publicly available collection for classifying diseases in plants. With an efficiency of 99.76%, these novel structures exceed the most recent findings for classifying plant illnesses. Additionally, we suggested using saliency maps as a visualisation technique to comprehend and decipher the CNN classification process.

III. A SMALL REVIEW ON SOFTWARE USED

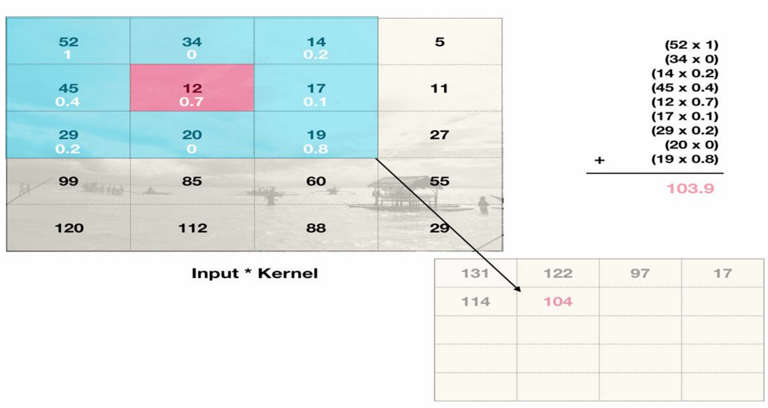
The Model Utilizes the technologies of the subset of machine learning which is called as the Deep learning, Computer Vision, Neural Networks(Convolution Neural Network) to extract the features of the Images for the give image and predict the accurate results.

A. *Deep Learning*

By learning to represent the world as a layered hierarchy of concepts, with each concept defined in relation to simpler concepts and more abstract representations computed in terms of less abstract ones, deep learning is a specific type of machine learning that reaches considerable power and flexibility. As artificial neural networks will imitate the human brain, deep learning is also a type of mimic of the human brain. Deep learning is a subfield of machine learning that is entirely based on neural networks. Deep learning is not a brand-new idea. It has been in existence for a while. It's popular now because we have access to more data and computing capacity than we did in the past. Deep learning and machine learning emerged as a result of the exponential rise in processing power over the past 20 years.

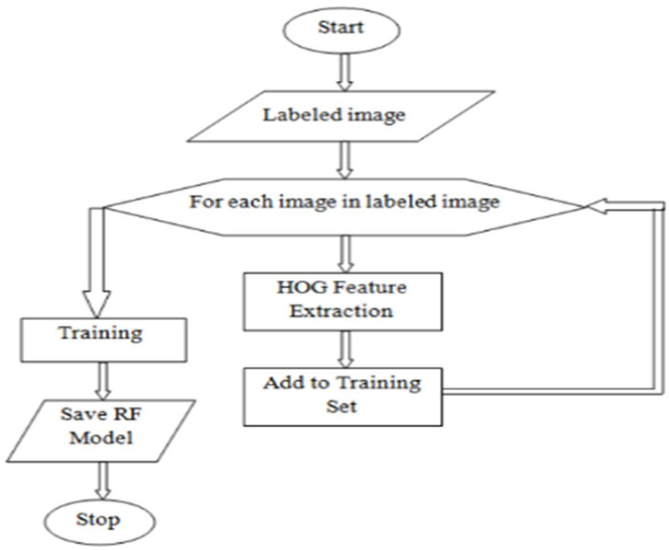
B. *Convolution Neural Networks*

The work we've done so far is applicable to any dataset whose inputs and outputs can be converted to fixed-length lists of integers. However, we have left out some really important details. The fact that there is significance in the pixel order is lost when we out flatten that image. Additionally, the arrangement of the pixels certainly has significance.
Convolutions can be used to record data about the arrangement of pixels. 2d discrete convolutions, which function like a weighted sliding sum over a region of pixels, are the kind of convolutions in which we are interested. A 3x3 matrix known as a kernel, for instance, can move over the pixels of an image. It computes the weighted sum of the values of the kernels and each pixel in the 3x3 block of the picture at each position. The total is then entered into the output image's initial value.



C. Convolution Neural Network's Classification

1) *Training of Image Size:* This is the First phase of CNN is to collect the different types of datasets for the image Recognition, The Dataset contains the Train Dataset and Valid Dataset which is classified as 39 classes of diseases. During phase one, we will look into how model performance is impacted by picture size. Five photos of various sizes, from 108 x 108 to 210 x 210, are evaluated in total. First, the trained models that served as Resnet34's trained weights are downloaded. In transfer learning, all layers—aside from the final two—are frozen by default. These have new weights and are specific to the classification job for plant diseases. Freezing enables these layers to be trained independently for each disease without backpropagating the gradients. The 1cycle approach is used just as previously described to train the final layers. Once this is finished, the other layers are removed. An analysis of a plot showing learning rate vs. loss is done to help with the fine-tuning process. The model is then run after choosing an appropriate learning from this. After recording the findings, the model is recreated for the other four picture sizes (Table III.). Every step, including the learning rate, is the same in every attempt.



IV. EXPERIMENTAL SETUP AND DATASET

Use the import statement in Python to import a file. A Python file import works similarly to a package import. There are two packages which are utilize to structure the Code in python. A Python file can be created first, and then it can be imported into any other file using the import statement.

A collection of Python bindings called OpenCV-Python is created to address issues with computer vision. An image is loaded using the cv2.imread () function from the given file. This function produces an empty matrix if the picture cannot be read (due to a missing file, poor permissions, an unsupported or invalid format, etc.).

Python's OS module offers a method for utilising operating system-specific capabilities. With the help of the OS module's capabilities, you may interact with any Windows, Mac, or Linux-based operating system that Python is running on.

This article demonstrates how to load data using the tf.keras.utils.image dataset from directory function and categorise floral photographs using a tf.keras.Sequential model. It exemplifies the following ideas:

The workflow for machine learning used in this lesson is simple:

1) Analyse and comprehend data
2) Create an entry pipeline
3) Create the model.
4) Educate the model
5) Analyse the model
6) Adapt the model and carry out the procedure again

The Report also shows how to use a saved model for on-device machine learning on mobile, embedded, and IoT devices by converting it to a TensorFlow Lite model.

The core of image classification, a deep learning phenomenon that gives a picture a class and a label that distinguishes it, are convolutional neural networks (CNNs).

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Input, output, and hidden layers are all features of CNNs that aid in the processing and classification of pictures. Convolutional, ReLU, pooling, and fully linked layers are among the hidden layers, and they all have a significant impact. Find out more information about convolutional neural networks.

Consider that an elephant is the input picture. The convolutional layers are initially applied to this pixel-filled picture. If the image is in black and white, it is read as a 2D layer, with each pixel given a value between '0' and '255', with '0' denoting fully black and '255' denoting wholly white. If the image is coloured, however, it transforms into a 3D array with three layers—blue, green, and red—each with a colour value between 0 and 255. The software then chooses a smaller picture known as the "filter" before starting to read the matrix (or kernel).

V. RESULTS AND DISCUSSION

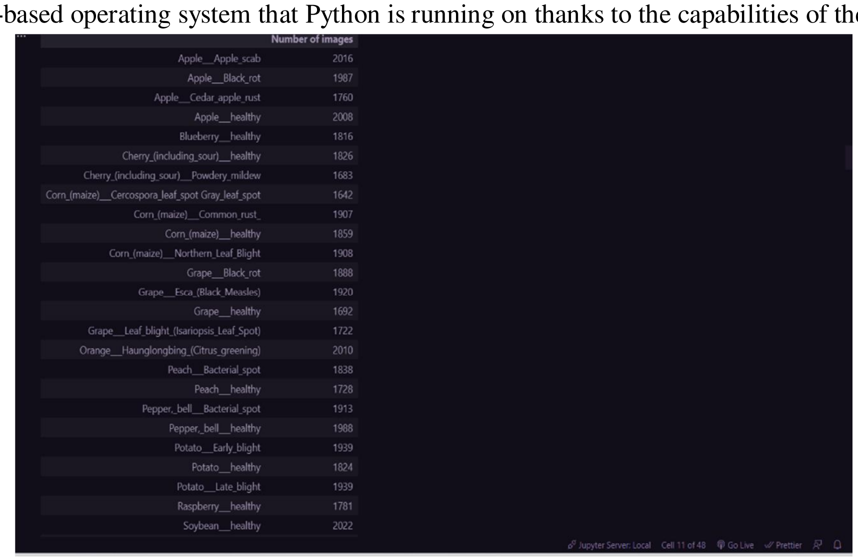
In this study, we've previously seen how different authors applied their ideas in a variety of methods, and we chose the most accurate method possible to forecast the facts about the disease using deep learning.

Fig 1. Printing Dataset in form of images

To import a file into Python, use the import statement. Similar to how a package is imported, a Python file is imported. Python uses both modules and packages to organise its code. The import statement may be used to import a Python file into any other file after it has been produced.

The OpenCV-Python library of Python bindings was developed to handle computer vision difficulties. The cv2.imread () function loads an image from the specified file. In the event that the image cannot be read, this method returns an empty matrix (due to a missing file, poor permissions, an unsupported or invalid format, etc.).

The OS module for Python provides a way to make use of operating system-specific features. You can communicate with any Windows, Mac, or Linux-based operating system that Python is running on thanks to the capabilities of the OS module.



	Number of images
Apple__Apple_scab	2016
Apple__Black_rot	1987
Apple__Cedar_apple_rust	1760
Apple__healthy	2008
Blueberry__healthy	1816
Cherry_(including_sour)__healthy	1826
Cherry_(including_sour)__Powdery_mildew	1683
Corn_(maize)__Cercospora_leaf_spot Gray_leaf_spot	1642
Corn_(maize)__Common_rust_	1907
Corn_(maize)__healthy	1859
Corn_(maize)__Northern_Leaf_Blight	1908
Grape__Black_rot	1888
Grape__Esca_(Black_Measles)	1920
Grape__healthy	1692
Grape__Leaf_blight_(Isariopsis_Leaf_Spot)	1722
Orange__Haunglongbing_(Citrus_greening)	2010
Peach__Bacterial_spot	1838
Peach__healthy	1728
Pepper,_bell__Bacterial_spot	1913
Pepper,_bell__healthy	1988
Potato__Early_blight	1939
Potato__healthy	1824
Potato__Late_blight	1939
Raspberry__healthy	1781
Soybean__healthy	2022

Fig 2. Representation of DataSet

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Convolutional neural networks are at the heart of image classification, a deep learning phenomenon that assigns a picture to a class and a label that distinguishes it (CNNs).

CNNs include several properties that help with the processing and categorization of images, including input, output, and hidden layers. Among the hidden layers are convolutional, ReLU, pooling, and fully connected layers, all of which have a big effect. Research convolutional neural networks in greater detail.

This pixel-filled image receives the initial application of the convolutional layers. When reading a black and white picture, each pixel is assigned a value between '0' and '255', with '0' signifying completely black and '255' signifying completely white. The image changes into a 3D array with three layers-blue, green and red each with a colour value between 0 and 255- however, if the image is coloured. Prior to beginning to read the matrix, the programme then selects a smaller image known as the "filter" (or Kernel).


Prediction

```
model1 = tf.keras.models.load_model('final_plantdisease_model.h5')

img = Image.open(r'./test/test/CorncommonRust3.JPG')
x = np.array(img.resize((180,180)))
x = x.reshape(1,180,180,3)
res = model1.predict_on_batch(x)
classification = np.where(res == np.amax(res))[1][0]
plt.imshow(img)
print(str(res[0][classification]*100) + '% Confidence ' + str(lab[classification]))
# print(label_encoder.inverse_transform([classification]))
```

Figure 3

VI. OUTPUT

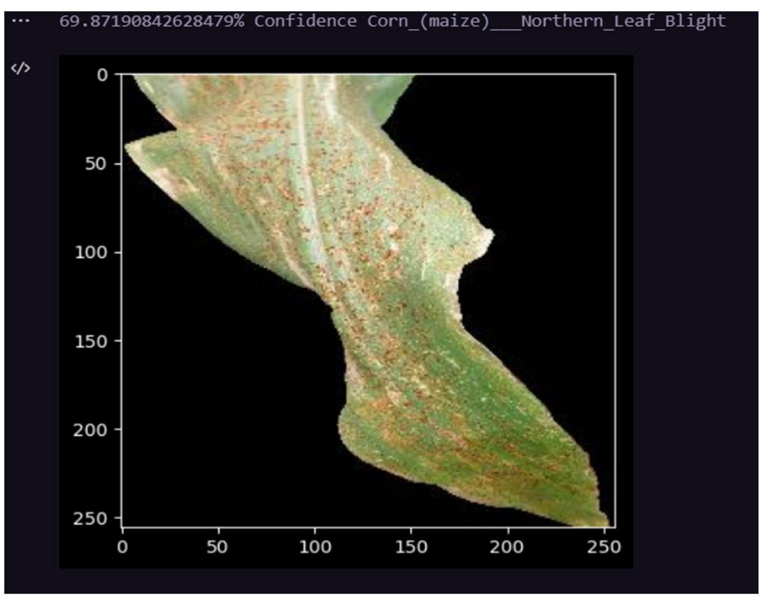

Figure 4

The training accuracy for our model has been attained at 97%, and the validation accuracy has been obtained at 93%, both of which indicate that our model is functioning as intended.

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Fig.5 is the view of accuracy and loss at a time in the single frame, where the loss is decreasing, and accuracy is increasing with epoch. Final goal of this research is to increase the accuracy of the model as compared to available models in the past ().

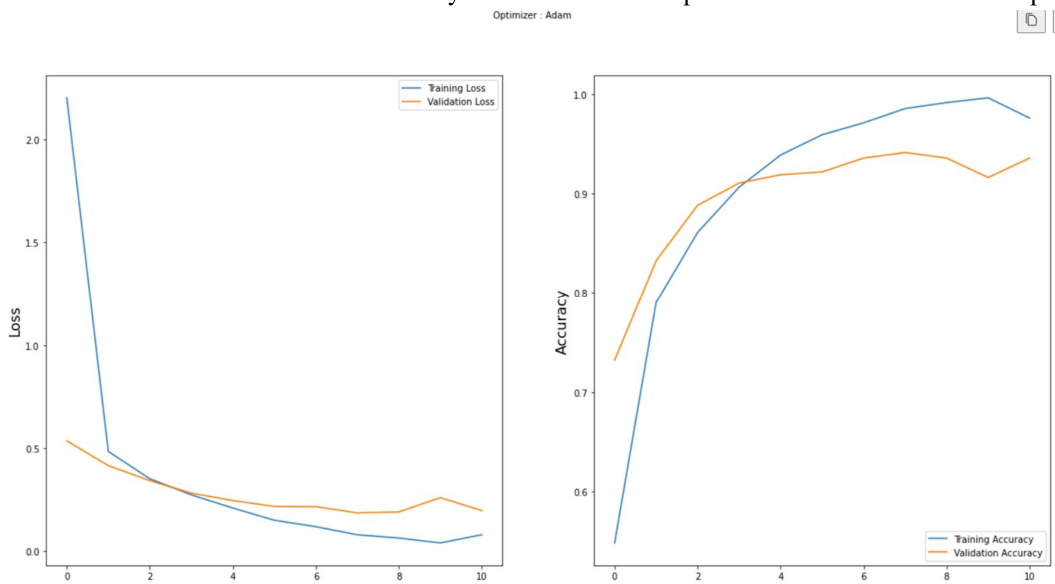

Fig 5. Comparison of loss and accuracy of the model

VII. CONCLUSION

The Overarching Goal and Motivation The goal of this project is to predict the disease of a plant because, in the modern world, agriculture is crucial to the nation's economy and the production of agriculture is largely based on crops and plants. However, if a plant contracts a bacterial or viral disease, it can be very challenging to identify the disease using conventional methods. Deep learning is a rapidly developing technology that has the capacity to predict disease. We want to employ regional photos and enhanced CNN models in further efforts to enhance classification performance. Additionally, in order to improve the database, we will collect photographs of various disorders. The development of a smart mobile device application that can identify numerous plant illnesses will be the major objective of following study. Users with little to no understanding of the plants they are farming might benefit greatly from this software, which will give automatic plant disease detection with visual examination.

The Trained model is essentially a software model, and this software model will be trained to hardware components like an Arduino uno in order to identify plant diseases. The hardware implementation provides us with more precise findings than the software does. The Educated model, to put it simply, is a computer software that will be trained to identify plant diseases utilising hardware components like an Arduino uno. The hardware implementation produces more accurate results than the application.