Plant Leaf Disease Detection Using Deep Learning

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Abstract: **World tomato yields are being threatened by climate change and disease, endangering food security and economic stability. Deep transfer learning through convolutional neural networks(CNNs) is employed in this research to differentiate nine wide spread tomato leaf diseases and healthy leaves using raw images alone without preprocessing. Through the use of pretrained models, the system performs well on a variety of evaluation metrics. The 10-repeated experiments to make them robust provided me and scores of 99.3% precision,99.2% F1 score,99.1% recall, and 99.4%accuracy.The result prove the efficiency of CNNs in the detection of diseases in agriculture and justify the construction of affordable, AI-powered tools for real-time diagnosis. The applications can help farmers and pathologists immensely in early disease control, especially in resource -poor settings, and thus minimize crop loss and enhance productivity. This work demonstrates the real potential of AI in sustainable agriculture.**

Keywords: **deep learning; tomatoes; virus; bacteria; blight; spot; mold; image classification; artificial intelligence.**

I. INTRODUCTION

For agriculture, one of humanity's most vital industries, to succeed, plant diseases must be controlled. Crop health has a direct impact on global political dynamics, economic stability, and food production. A vital crop because of their high nutritional content and many culinary uses, tomatoes are especially vulnerable to a wide range of illnesses. The Food and Agriculture Organisation (FAO) reports that tomatoes are the sixth most abundant vegetable in the world, with a global production of about 170.8 million tonnes in 2017 [1][2][3]. Tomatoes, like many other crops, are susceptible to bacterial, fungal, and viral diseases that can significantly lower crop quality and yield [4].

To identify plant diseases, farmers have historically relied on plant pathologists or their own knowledge. However, in rural or developing regions, where access to agricultural specialists is limited, this process is frequently labour-intensive, slow, and requires a level of expertise that may not be available [5]. Recent developments in artificial intelligence (AI), especially deep learning, have created new avenues for quick, precise, and automated disease detection. In tasks like image classification, object detection, and pattern recognition—all of which are critical for identifying plant diseases—deep learning algorithms, like Convolutional Neural Networks (CNNs), have demonstrated exceptional efficacy [6][7][8].

CNNs are a subset of deep learning algorithms that are particularly good at handling image data. Multiple layers make up these networks, which automatically extract features from the input images. CNNs can process raw image data and recognise hierarchical features without the need for manual feature extraction, in contrast to traditional machine learning techniques. CNNs are especially well-suited for identifying plant diseases, as symptoms frequently appear visually on plant leaves, due to their capacity to capture image details at different scales, orientations, and colours [8]. Many agricultural AI systems have effectively implemented CNNs, which offer quicker and more accurate disease detection than conventional techniques.

Transfer learning, which enables pre-trained models like VGG16, ResNet, and MobileNetV2 to be modified for particular tasks like plant disease classification, is a major benefit of CNNs. The time and computational resources required for training are decreased by transfer learning, which reuses the weights and parameters of these pre-trained models. Transfer learning has proven to be successful in detecting plant diseases in a number of studies; models have been shown to classify diseases from photos of plant leaves with high accuracy [9]. For instance, Kumar and Vani [12] reported a 99.25% accuracy using VGG16, while Mim et al. [10] developed a system using CNNs to classify tomato leaf diseases with a 96.55% accuracy.

II.PROPOSED SYSTEM

As a remedy for farmers, we suggest employing the most recent image processing technologies to identify plant diseases. The objective is to create a Python-based application that will allow farmers to submit pictures of their leaves, process the photos, identify the disease, and provide details about the disease type and affected area, as well as accuracy scores. The goal of this system is to offer a rapid, economical, and ecologically responsible method of categorising leaf diseases [1].

Convolutional Neural Networks (CNNs), the system's central component, are highly effective at classifying images. High-resolution pictures of plant leaves taken in a variety of settings start the procedure. To enhance generalisation and lessen overfitting, these photos undergo preprocessing using resizing, normalisation, and data augmentation techniques. In order to categorise illnesses like bacterial spot or early blight, the CNN will automatically extract features from the photos. To increase accuracy and speed up training, transfer learning will be used to refine pre-trained models like ResNet50, VGG16, and MobileNetV2 [2].

Labelled data will be used to train the model, and metrics such as accuracy, precision, recall, and F1-score will be used to assess performance. After training, the model can be put to use on web or mobile platforms that allow users to upload photos and get real-time recommendations for treatments and disease diagnoses. For users in places with poor internet access, the system can operate offline or online through a cloud backend [3].

To sum up, the suggested system makes use of deep learning to provide a scalable and intuitive way to detect plant diseases. The system can assist farmers in decreasing crop loss and improving sustainable agricultural practices by offering prompt diagnosis. With regular dataset updates and possible IoT sensor integration, the system may develop into a complete precision agriculture tool [4].

III.METHODOLOGY

Identifying diseases in plant leaves using traditional methods is often slow and unreliable, especially when images are noisy or taken in poor conditions. These older techniques usually require a lot of manual effort and still may not deliver accurate results. To solve this, a smarter approach using deep learning has been introduced. It starts by gathering a wide range of clear, high-quality images of both healthy and diseased leaves. These images are then cleaned up and prepared through resizing, color adjustments, and other enhancements to help the model learn better. Extra steps like removing backgrounds are also taken, especially when the photos come from real farming environments.

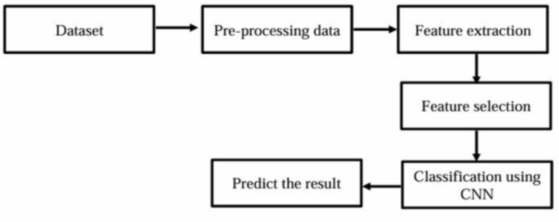


Figure 1: Proposed diagram

The system then uses powerful deep learning models, particularly Convolutional Neural Networks (CNNs), to identify the disease shown in each leaf image. These models, whether built from scratch or fine-tuned from existing ones like ResNet or MobileNet, are trained to recognize key patterns that distinguish different diseases. Once the model is accurate enough, it can be turned into a mobile or web app. This allows farmers to simply snap a picture of a leaf and get a fast, reliable diagnosis with suggestions for treatment. This smart system helps farmers protect their crops more effectively, reduce waste, and move toward more sustainable farming practices.

IV.IMPLIMENTATION

Types of Diseases:

It terminates various kinds of diseases that are affecting the plants. The frequent diseases among the plants are Alternaria alternate (fungal), Anthracnose, Bacterial Blight (bacteria), and Cercospora Leaf Spot, Downy Mildew, Alternaria Leaf Spot, Frogeye Leaf Spot, White Spot, Powdery Mildew [5].In our system we considered just three kinds of plant diseases which are the following:

Alternaria Alternata:

It is among the well-known diseases affecting plants, it is a type of fungus causing spots in the leaf of a plant, it has undesirable effects on both plant health as well as on a human in terms of maybe bringing asthma for both [5].

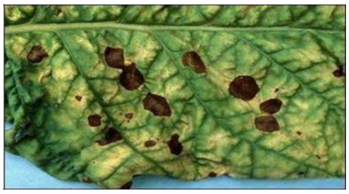


Figure 2: Image of Alternaria Alternata disease

Bacterial Blight:

Necrotic blotches are another symptom of this dangerous disease, which can first be observed on a plant's leaf as dark, yellow spots [5].

Figure 3: Image of Bacterial Blight disease

Data Collection:

Our collected data contains different images of the leaf diseases that were taken from the internet, and these images are stored as a database in the computer, and they are used also to train our system along with the healthy leaf images.

Below are samples of images of the three diseases that we picked for our dataset.

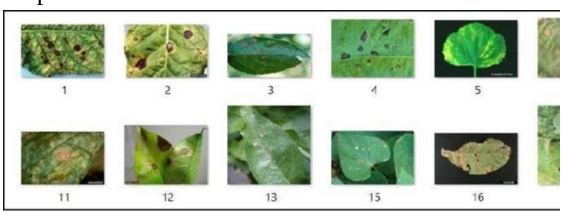


Figure 4: Sample Images of Alternaria Alternata

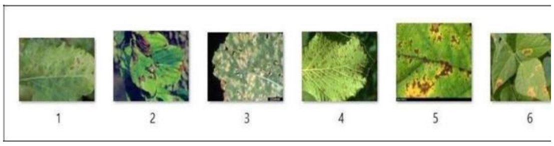


Figure 5: Sample Images of Bacterial Blight

Image Processing:

Image processing is a technique that employs computerized algorithms to examine the images and process them. Agriculture has extensively utilized image processing, especially in the detection of plant diseases. Image processing consists of several steps, which are discussed below.

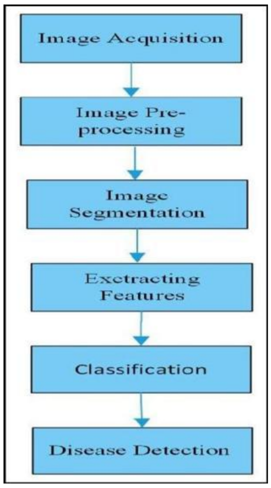


Figure 6: Block diagram of the image processing step

Image Acquisition:

Image acquisition is the first phase of image processing. Here, in this step, a digital camera or a camera phone is employed to capture images of the leaves of the plant. These images must be stored on the computer since they serve as input to the system.

Image Pre-processing:

This is essentially the process of improving the input images for processing. This pre-processing improves the quality of images by eliminating unwanted distortion such as the spores, dust. It may also be utilized to modify the colors of the images. The goal of this process is to deliver good images for subsequent analysis. Essentially, in this phase the input image is transformed from RGB image into L*a*b* color space (L* = Luminosity layer, a* & b* chromacity layers).

Image Segmentation:

At this stage, an image is divided into smaller images, or the input image is segmenting. Various methods are utilized for segmentation, such as: edge detection segmentation, region-based segmentation, and K-mean clustering [8]. But the K-mean clustering is most commonly utilized. The basic aim of this method is to divide n observations into k clusters, where every observation belongs to the cluster having the nearest mean. Each pixel in the uploaded image is labelled based on the k-means results, and the clustering results are then saved in a blank cell array. One of important things in this step is to choose the convenient cluster. We select this cluster based on the one that shows the big part that is affected by the disease. Then, the features of the chosen cluster are to be extracted in the following phase which is the feature extraction. Basically, segmentation serves to separate the region that the disease allocates on the leaf image from the non-disease region.

Feature Extraction:

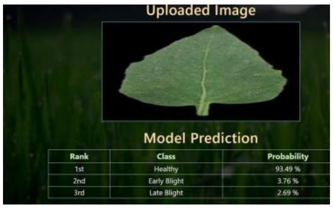
During this stage, it is now the time to pull out the required information from the image. The size of the region of interest (ROI) is smaller than that of the original image. It is a wide variety of methods that are employed for the feature extraction, but the one most often used is the Gray Level Co-occurrence Matrix. The GLCM is famous for extracting the texture features that will facilitate any subsequent analysis.This method calculates the pixel with a specific intensity with the image. The chosen image will be converted to grayscale as it is originally in RGB format.

Classification:

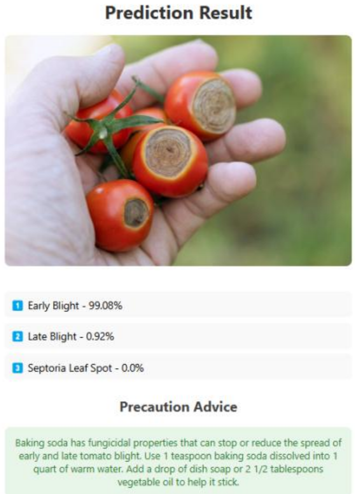
The diseases common to afflict the leaves are fungi, bacteria, and viruses or even the effect of insects that is commonly represented as spot leaves. With the SVM method the disease might be classified.

The support vectors machine is to be trained using images of different diseases with their features that are extracted and these images which are a part of the training are saved in the dataset, they refer to them as training images. This table below illustrates the dataset that was trained with the SVM classifier and it represent simultaneously the database reference to which the SVM classifier refers to in order to compare the vector features.

RESULT



The picture displays a tomato leaf that has obvious signs of disease, such as yellowing and dark, irregular spots that are frequently linked to Septoria Leaf Spot (Septoria lycopersici) or Early Blight (Alternaria solani). These fungal infections gradually harm the leaf and frequently manifest as concentric ring patterns. It is advised to take immediate action, including removing afflicted leaves to stop the disease from spreading, using fungicides like chlorothalonil or copper-based treatments, and enhancing environmental factors like irrigation techniques and air circulation to reduce moisture retention on foliage.



V.CONCLUSION

The simplest manner in which effective yield can be sustained is by applying image processing for plant disease detection. The main aim of this paper was to establish how image processing tool can ensure quality results in the sense of the detection of plant diseases and further how it can help the farmers in improving the yields. By the conclusion of this project, we managed to attain the purpose intended that was the implementation of image processing in the Identification of plant diseases. In addition, the construction of the standalone application

will enhance the usability of this technology as well as its practicability to the farmers.As a result, the standalone application for identifying disease-affected plants an healthy plants has been developed

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