Green Tech: An Android Application for the Automatic Identification of Potato Leaf Diseases using Deep Learning.

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Abstract: Research on sustainable agricultural development is becoming more and more significant owing to the advancements in agricultural technology and the use of artificial intelligence to diagnose plant diseases. Potato is an extensively consumed food corp worldwide, with India being one of the biggest producers. However, numerous diseases, particularly leaf diseases like early blight and late blight, have a substantial negative influence on the quality and quantity of potatoes. Manual interpretation of these diseases is inconvenient as the process is time-consuming and requires high expertise. Thus, the researchers are working on automatizing leaf disease detection in real time. In this work, we have presented an Android application for classifying a potato leaf into - healthy, early blight or late blight categories. A deep learning model based on a pre-trained VGG 16 model was designed for classification purposes. Transfer learning is also applied in detecting leaf diseases in several other plants. The model was fine-tuned using a dataset containing 1500 potato leaf images with 900, 300 and 300 train, test and validation images respectivelyFinally, the model was converted into a TFlite file for integration and deployment in Android Studio. Experiments showed promising results with an obtained accuracy of 98%.

Keywords: Deep learning, transfer learning, VGG-16, classification, early-blight, late-blight.

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I. Introduction

The potato is a significant crop that is widely consumed throughout the world. It is the third-most consumed food after wheat and rice. According to the Food and Agriculture Organization's Corporate Statistical Database , India is the second-largest producer of potatoes after China, with Uttar Pradesh and West Bengal being the major producing states [1]. However, the potato crop is susceptible to several diseases, including leaf diseases such as early blight (Phytophthora infestans) and late blight (Alternaria solani). Timely detection and diagnosis of these diseases are critical for limiting disease spread and minimizing yield loss. Though traditional visual inspection is the most common and popular method for identifying plant leaf diseases, it is undeniably intuitive, inefficient, and requires high expertise [2,3]. As a result, it is essential to develop a rapid, inexpensive, and efficient method for automatic potato leaf disease detection.

With the progress in artificial intelligence, and machine learning, it has become possible to develop and implement automated disease detection techniques in plants. Many plant diseases result in visible patterns on plant leaves, which image processing methodologies can recognize. In most cases, these patterns are disease-specific and thus can be utilized as features for disease classification using various machine-learning techniques. Consequently, the combination of image processing and machine learning is extremely effective for the fast and precise detection of plant leaf diseases without human intervention. Recently, deep learning technology has been extensively used in agriculture and has proven to be an effective method for continuous plant health monitoring[4, 5]. Moreover, with the evolution of the Android framework, Tensorflow-based deep learning models can now be readily integrated with a wide range of mobile devices. A wide range of mobile devices are compatible with TensorFlow Lite models because they use very few hardware resources [6]. An automated Android application for plant leaf disease detection can be of great assistance to farmers by enabling them to diagnose the diseases and take appropriate measures to prevent crop loss. However, the most challenging aspect of deep learning is the need for a vast quantity of data. In such circumstances, transfer learning can enhance the efficacy of the model by accelerating the training process using a pre-trained model [7].

In this study, we have designed a classification model based on a pre-trained VGG-16 model. The trained model was then integrated into an Android application that allows users to capture or upload images of potato leaves. The user can then check whether the leaf is healthy or infected. The proposed model was trained and tested using potato leaf data from the Plant Village dataset. Experiments showed promising results, with an accuracy of up to 98%

The remainder of the article is structured as follows: related work is presented in Section 2, materials and methods are described in Section 3, results and discussion are described in Section 4, and Section 5 contains the conclusion, followed by the references.

II. Related work

Recently, due to the advancement in technology, extensive research has been carried out in the agriculture sector to improve the yield and quality of food crops. Early detection of crop diseases is important to minimize yield loss. The researchers have recommended different approaches for identifying leaf diseases in their work. An overview of those methods is provided in this section.

In [8], AI-Bashish D, M. Braik, and S. Bani-Ahmad used K-means and neural network-based approaches for the automated identification of plant diseases. Kawcher Ahmed et. al used machine learning to identify rice leaf disease detection [9] . The algorithm used for this purpose were KNN (K Nearest Neighbor), J48(decision tree), Naïve Bayes, Decision tree algorithm, and Logistic Regression. Higher accuracy was found in this paper by the use of efficient algorithms. Z. R. Li and D. J. He, [10] selected 5 kinds of apple leaf diseases (speckled deciduous disease, yellow leaf disease, round spot disease, mosaic disease, and rust disease). They extracted features of the apple leaf spot image, such as colour, texture, and shape. Then neural network model was used to classify and recognize the diseases, and the recognition accuracy was 92.6%

Thakre G, More A, Gajakosh K, Yewale M, Shamkuwar D [11], developed a mobile application for plant disease recognition using image processing. The k-means clustering algorithm was implemented to identify the diseases. The authors claimed to have achieved 90% accuracy for their model using a small training set.

III. Proposed methodology

A classification model based on transfer learning has been proposed in this study. Additionally, an Android application was also developed to assist the farmers in monitoring the health of potato leaf images by uploading images. In this section, we describe in detail the methods and materials used in our experiment.

A. Dataset Description

The Plant Village Dataset is available for study through the open-source repository Kaggle (https://plantvillage.psu.edu/). Approximately 55,000 labelled images of healthy and infected leaves from various fruits and vegetables are included in the dataset. For this study, we used a dataset containing 1,500 images of potato leaves. The dataset is divided into three parts- training, test and validation. Each portion contains images from the three categories- healthy, early blight and late blight. Table 1 presents the number of images within the specified dataset across the three categories: healthy, early blight, and late blight. Fig. 1 shows one sample image from each category. The training and validation datasets were used to train and fine-tune the classification model, while the test dates were used to evaluate the model's accuracy.

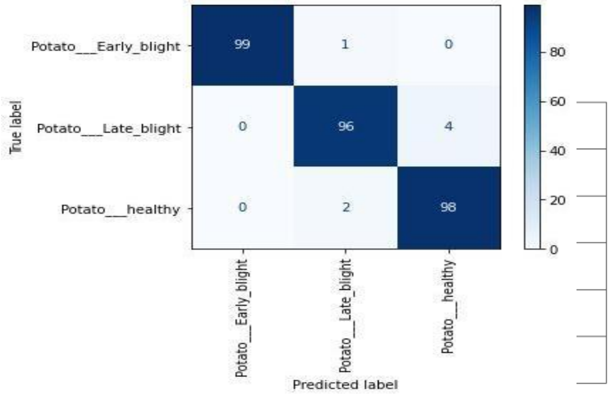

Fig 3 . Confusion matrix for classification

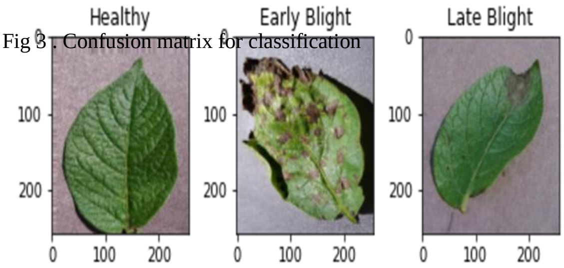

Fig 1. Sample potato leaf images from the three classes- healthy, early blight and late blight

B. Classification Model

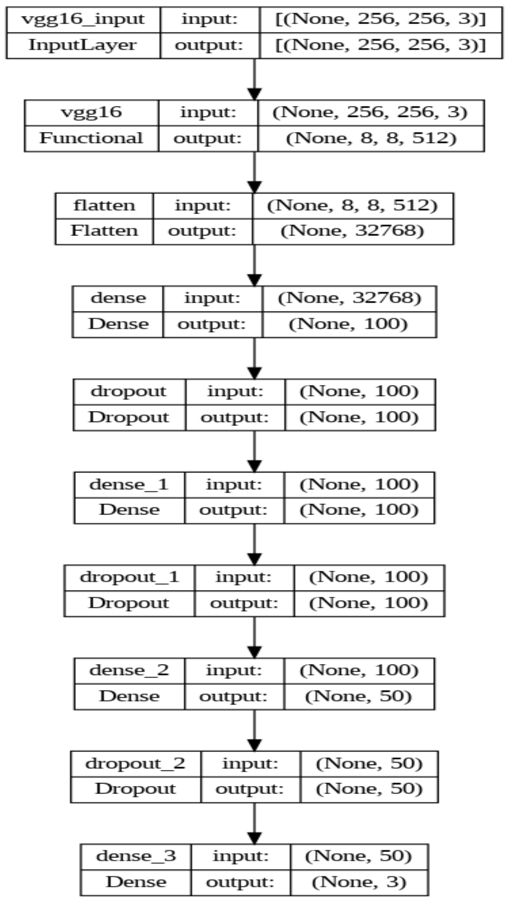

Fig 2. Block diagram of the proposed classification model.

II. AUGMENTATION USED IN THE MODEL

Width	0.2
Height shift	0.2
Horizontal flip	True
Vertical flip	True
Rotation Range	10

In 2014, researchers at Oxford University proposed the VGG16 architecture for deep convolutional neural networks [12]. VGG16 has 16 layers, 13 of which are convolutional and 3 fully connected. Due to its high accuracy and comparatively simple layout, the VGG16 architecture is often used as a benchmark for image classification tasks. VGG16 was initially trained on the ImageNet dataset [13], which consists of over one million images and one thousand object categories. The pre-trained weights of VGG16 are frequently employed for transfer learning in a variety of computer vision tasks, including object detection, image segmentation, and image classification [14].

In the proposed classification model, VGG-16 has been used as the base model, followed by four dense layers. Fig. 2 presents the architecture of the designed classification model.

Before training the model, data preprocessing and augmentation were applied to the training dataset. The details of data augmentation are given in Table 2.

C. Android Application Design

To automate the process of potato leaf disease detection, an Android application named "Green Tech" was developed using Android Studio, Java, and TensorFlowLite. TensorFlowLite is an API that helps integrate machine learning models into Android apps. Using this application, the users could upload or capture a potato leaf image, which is fed to the trained model as input. The application then retrieves the model's output and displays it on the user's home screen.

IV. RESULTS AND DISCUSSION

The study consists of two parts-first is the development of the classification model using transfer learning and then the development of an Android application to automate the disease detection process. In this section, we present the results of both phases.

A. Accuracy of the Classification model

The classification model based on transfer learning and VGG16 was trained multiple times by varying batch size, learning rate, and optimizer, among other parameters. The batch size and learning rate of the final model were set to 32 and 0.001 respectively. Adam and binary cross entropy were utilised as the loss function and optimizer, respectively. The number of epochs with early stopping was set to 50.

III. CLASSIFICATION REPORT OF THE EXPERIMENT

Class	**Accuracy Metrics**		
	Precision	***Recall***	***F1-score***
Healthy	1.00	0.99	0.99
Early Blight	0.97	0.96	0.96
Late Blight	0.96	0.98	0.97
Accuracy	0.98	0.98	0.98

The model was tested with a total of 300 potato leaf images with 100 images each from healthy, early blight and late blight. The highest accuracy achieved using the model was 98% at epoch 26. Table 3 shows the classification report of the model and Fig. 3 presents the corresponding confusion matrix.

B. Green Tech Application user interface and features

Fig. 4 depicts the user interface and features of the "Green Tech" mobile application. The application consists of numerous pages and features.

Fig 5. Display of classification results by the application on user mobile phone.

The home page is the first page of the application. There are four buttons on the homepage—Detection, Disease info, Treatment, and About app. The "About app" button shows basic information about the application. The "Detection" button takes the user to the image-scanning page. It is the main module of the application. There are two ways to load an image: either by capturing a new image with the camera or by loading a previously captured image from the gallery. After that, the app displays the health of the input potato leaf image. Fig. 5 shows the images of classification results. If it is infected, then the application redirects to the "Treatment" page, which contains the possible remedies for the disease. Apart from that, the home page also has a "Disease info" button, which displays information about early and late blight disease.

V. Conclusion

Maximizing crop productivity through accurate leaf disease identification is important. This paper focused on the detection of potato leaf diseases using the VGG-16 model and transfer learning techniques. By utilizing the fine-tuned model an accuracy of 98% was achieved in identifying the potato leaf diseases- healthy, early blight, and late blight. The achieved accuracy of 98% demonstrates the effectiveness of the proposed approach in accurately classifying potato leaf diseases. Such high accuracy is crucial for early detection and timely intervention, which can significantly mitigate the impact of diseases on potato crop yields and quality. This accuracy level is a promising sign for the potential deployment of this system in real-world scenarios, such as automated disease monitoring on large-scale potato farms. The findings of this study provide a solid foundation for further research and development in the field of agricultural disease monitoring, aiming to improve crop management practices and mitigate losses caused by diseases in potato farming.

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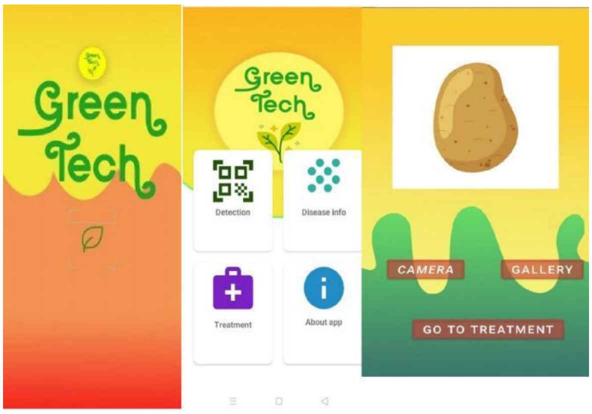

Fig 4. Green Tech User Interface

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