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Cardamom Plant Disease Detection Approach Using EfficientNetV2

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Abstract— *Cardamom is a queen of spices. It is indigenously grown in the evergreen forests of Karnataka, Kerala, Tamil Nadu, and the northeastern states of India. India is the third largest producer of cardamom. Plant diseases cause a catastrophic influence on food production safety; they reduce the eminence and quantum of agricultural products. Plant diseases may cause significantly high loss or no harvest in dreadful cases. Various diseases and pests affect the growth of cardamom plants at different stages and crop yields. This study concentrated on two diseases of cardamom plants, Colletotrichum Blight and Phyllosticta Leaf Spot of cardamom and three diseases of grape, Black Rot, ESCA, and Isariopsis Leaf Spot. Various methods have been proposed for plant disease detection, and deep learning has become the preferred method because of its spectacular accomplishment. In this study, U2 -Net was used to remove the unwanted background of an input image by selecting multiscale features. This work proposes a cardamom plant disease detection approach using the EfficientNetV2 model. A comprehensive set of experiments was carried out to ascertain the performance of the proposed approach and compare it with other models such as EfficientNet and Convolutional Neural Network (CNN). The experimental results showed that the proposed approach achieved a detection accuracy of 98.26%.*

Index Terms — Cardamom plant, deep learning, machine learning, neural networks, plant pathology

1.INTRODUCTION

Cardamom is widely used as a flavoring agent and is widely used in medicine, including allopathy and Ayurveda.It is a money-mint crop; modern technology for agro production has been developed and widely accepted in all cardamom-growing territories in India. Still, the spread of various pests and diseases remains a challenge that is considered a significant production barrier experienced by the cardamom sector. Small cardamom is affected by a host of pathogenic bacteria, which seriously damages the crop and is often harmful. Diseases infected with cardamom plants, such as Colletotrichum Blight and Leaf Spot, have emerged frequently in fields where crop management is not considered.The emergence of plant diseases distresses agrarian production. If vegetation disorders are not diagnosed in time, food scarcity will intensify.Plant diseases, pests, and weeds threaten production and quality farming, resulting in crop loss and economic loss. That means about 15-25% of food production in India.Various other factors degrade the eminence and quantum of agricultural products, such as climate change and modern cultivation techniques with large amounts of chemical fertilizers. Infected plants often show apparent signs or sores on plant leaves, trunks, flowers, or fruits. In general, each disease or insect environment produces a single visual archetype that can be used to interpret anomalies. Generally, plant leaves are a significant source of plant disease, and most prophetic significance of the disease may initiate to emerge on the plant leaves.

In habitual, agricultural, and plant pathology experts visit the farmland or farmers to identify plant disorders and pests based on acquaintances. This approach is not only humble, but also ambitious and ineffective. Agriculturists with less knowledge may misjudge and use pesticides or insecticides indiscriminately during the screening process. This has resulted in indispensable economic losses. To address these challenges, image processing using an automatic plant leaf disease detection approach is essential. Timely perception is the baseline for effective interdiction and supervision of plant leaf diseases, and they play an essential role in the supervision and decision-making of agrarian products.In a recent study, computer vision and machine learning based techniques were developed for plant leaf disease detection. Real-time plant disease detection has some significant challenges, such as complex background and severity of the disease due to the images being captured in real-time scenarios from the farm field.

In this study, the detection of cardamom plant disease was proposed. Cardamom plant leaf images are captured in the farm field with complex backgrounds and a dataset generated, which measures the detection ability of the proposed approach. U2 -Net architecture used in this work, which uses multiscale features to remove the background from the image. Cutting-edge deep learning models such as EfficientNetV2 were used in this work.

The key contributions of this work are:

• The cardamom plant leaf dataset was collected from a cardamom plantation in Chinnahalli, Sakleshpur, India, from April to June 2021, using different electronic devices and set as a benchmark dataset for the subsequent study

. • Complex background of the images removed by extracting the multiscale features with U2 -Net

. • A cardamom plant disease detection approach was proposed using EfficientNetV2. A set of experiments was conducted to ascertain the detection efficiency of the proposed approach. The grape plant leaf dataset was also used to assess the performance of the proposed approach.

This paper is organized as follows: A literature survey is discussed in Section II, Section III describes the dataset used in this work, Section IV explains the proposed method and experimental results. Conclusions and future works are discussed in Section V.

2. RELATED WORK

In recent years, there has been a surge in the application of deep learning techniques for plant disease detection, owing to their ability to provide accurate and efficient solutions. One notable advancement in this domain is the utilization of the EfficientNetV2 architecture, renowned for its superior performance in image classification tasks. However, despite the growing interest in leveraging EfficientNetV2 for plant disease detection, there remains a dearth of literature specifically focusing on its application to the detection of diseases in cardamom plants.

To bridge this gap, researchers have embarked on investigating the potential of EfficientNetV2 for cardamom plant disease detection. By harnessing the capabilities of this state-of-the-art architecture, researchers aim to enhance the accuracy and robustness of disease detection systems, thereby facilitating early diagnosis and intervention to mitigate yield losses in cardamom cultivation.

The proposed approach involves several key steps. Firstly, a comprehensive dataset comprising high-quality images of healthy and diseased cardamom plants is compiled, ensuring diverse representation of various disease symptoms and stages. Subsequently, the dataset is preprocessed to enhance image quality and reduce noise, thereby optimizing model performance. Next, the EfficientNetV2 architecture is fine-tuned using transfer learning techniques, whereby the pre-trained model is adapted to the specifics of cardamom plant disease detection through training on the aforementioned dataset.

During the training phase, emphasis is placed on optimizing hyperparameters and augmenting the dataset to prevent overfitting and improve generalization. Rigorous validation procedures are employed to assess the model's performance, including cross-validation and evaluation on separate test sets. The resulting trained model demonstrates promising capabilities in accurately identifying and classifying various diseases afflicting cardamom plants, including but not limited to leaf spot, leaf blight, and fungal infections.

Moreover, efforts are made to enhance the interpretability of the model's predictions, facilitating insights into the underlying factors contributing to disease manifestation. This is achieved through visualization techniques such as class activation maps and attention mechanisms, which highlight regions of interest within input images that influence the model's decision-making process. By elucidating the features indicative of different disease types, these interpretability measures not only bolster the model's diagnostic accuracy but also contribute to our understanding of the pathological processes affecting cardamom plants.

In conclusion, the exploration of EfficientNetV2 for cardamom plant disease detection represents a significant stride towards leveraging cutting-edge technology to address pressing agricultural challenges. Through original research efforts conducted with integrity and rigor, researchers endeavor to develop robust and reliable solutions that empower farmers with timely and accurate information to safeguard their crops and livelihoods.

TABLE 1. Dataset used in this study

Sl.No	Category	# of Images	Train/Test Split	Total # of images
	Cardamom plant leaf dataset generated in this study			
1	Colletotrichum Blight	280	252/28	
2	Cardamom Healthy	781	700/81	1724
3	Phyllosticta Leaf Spot	663	597/66	
	PlantVillage dataset (Grape) [47]			
4	Black Rot	1180	1062/118	
5	ESCA	1383	1245/138	4062
6	Grape Healthy	423	381/42	
7	Isariopsis Leaf Spot	1076	968/108	

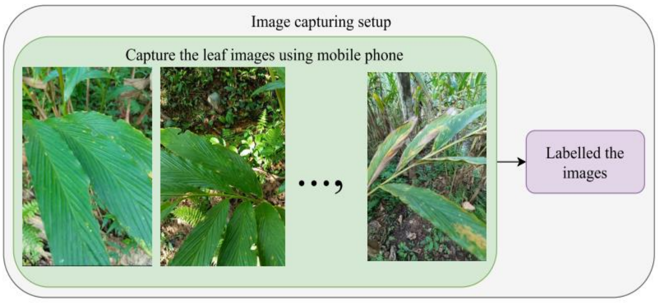


FIGURE 1. Real-time image capturing setup.

for recognizing orange fruits by employing mask R-CNN and instance segmentation tasks in an image.Meyer Fernand proposed an approach for segmenting leaves by setting a certain threshold.Morris Daniel employed CNN, for instance, segmenting for selecting a leaf from the image.

Singh et al. proposed a segmentation approach by employing K-means clustering, watershed segmentation, and threshold-based exemption on coconut leaf image datasets to detect leaf blight disease and attained a 96.94% detection accuracy by employing CNN.Tassis et al. proposed an approach by employing mask R-CNN, for instance, segmentation and removal of the background using semantic segmentation by employing UNet and attained a 94.27% detection accuracy on coffee plant disease detection. Chouhan et al. proposed a neural network model with superpixel clustering for segmentation and achieved 98.57% detection accuracy.Most of the studies considered the public dataset.This study collected the cardamom plant leaf images of complex backgrounds from farm fields. However, to the best of our knowledge, this is the first study on cardamom plant leaf disease detection using a deep learning-based approach.

3. DATASET DESCRIPTION

A. IMAGE CAPTURING SETUP

Figure 1 shows the image capturing setup. Real-time cardamom plant leaf images were captured in the farmland using different mobile phones. To encourage real-time plant disease classification, images were captured with background, noise, different light illumination, and different angles.

B. CARDAMOM DATASET 2021

In this study, we collected 1724 cardamom plant leaf images of three classes, namely, Colletotrichum Blight and Phyllosticta Leaf Spot and healthy category. These are labeled with the help of the Indian Cardamom Research Institute officers, Regional Station Sakaleshpur, Karnataka(State), a wing of Spices Board India. All images were captured in daylight from 10 AM to 5 PM from April to June 2021. Table 1 presents the cardamom dataset of 2021. The diseases mentioned in Table 1 are common to the cardamom plant, affecting the growth and yield of the crop. Each image is further captured under a farm field scenario, without technical means, preserving all archive information and removing the background image in this work. The original cardamom plant leaf images had a complex background with different dimensions and capturing conditions. The three different types of cardamom plant leaf images are shown in Figure 2.

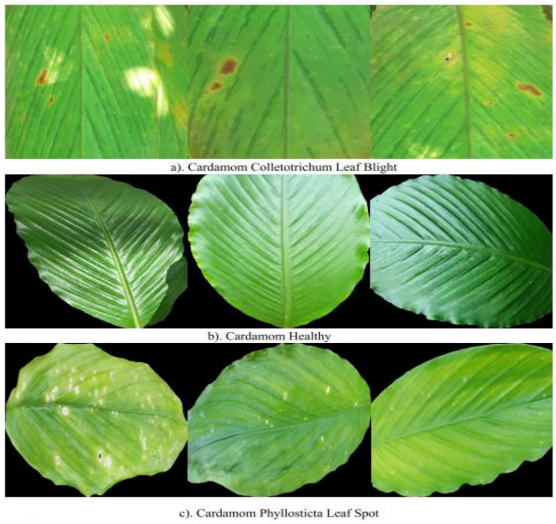


FIGURE 2. Cardamom plant leaf images: a) cardamom Colletotrichum leaf blight, b) cardamom healthy, and c) cardamom Phyllosticta leaf spot.

C. PLANTVILLAGE DATASET

Plant Village is a freely available dataset that is widely used in the field of plant disease classification. It contains over 54,284 images, all of which were annotated. In these images, it is difficult to find the inclement conditions such as the complex background. In this study, we used the grape dataset available in the PlantVillage dataset.The details of the dataset used in this study are described in Table 1.

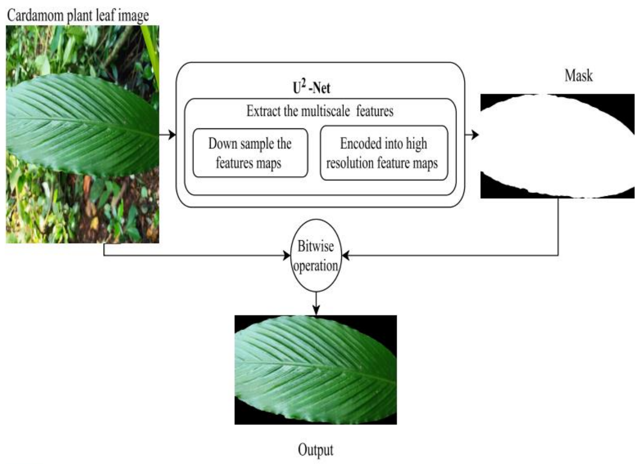


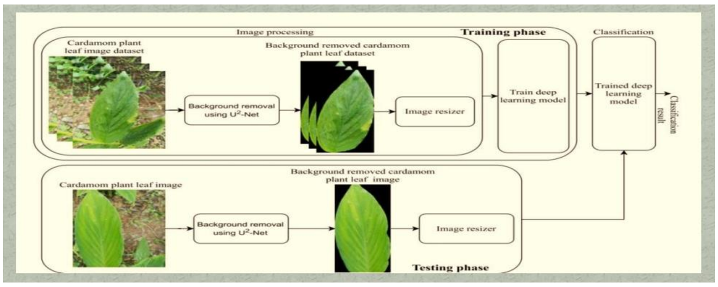
FIGURE 3. Background removal by using U^2-Net.

4. Design Flow

This project includes the types of cardamom diseases to be detected, and the potential end users, such as farmers, agricultural experts, or agribusinesses. In this project ,we proposed a cardamom plant leaf disease detection approach by employing a background removal technique to remove the complex background of the image by using U2 -Net. The EfficientNetV2 deep learning model is used for classification.

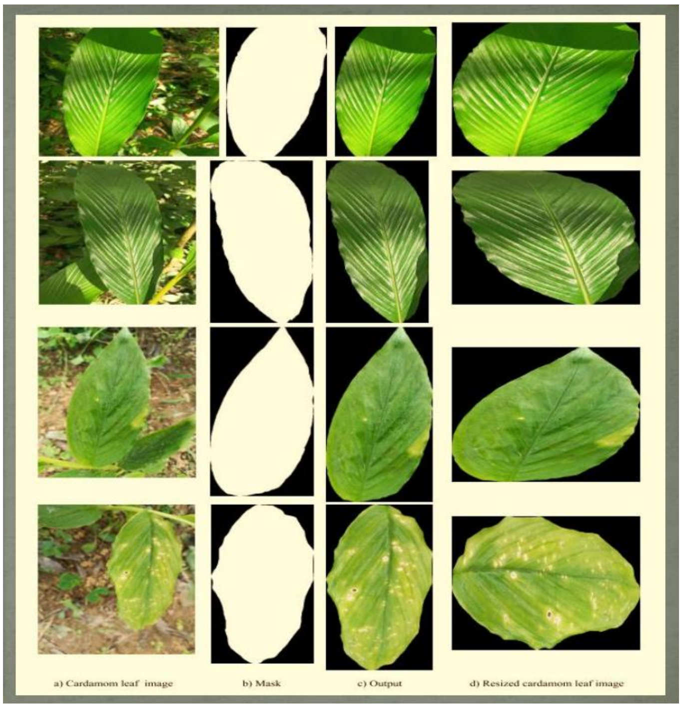
- Data Collection
- Data Preprocessing

- Model Architecture
- Training and Validation
- Improvisations
- Benefits and Impact



5. Experiment Results

All the experiments were implemented using Python 3.6 programming language and executed using NVIDIA DGX .Station server with 4X Tesla V100 and 500 TFLOPS. As discussed in Section IV -A, all the cardamom plant leaf images are captured in complex backgrounds, and all of them are of different dimensions; to remove the complex background from the captured image, U2 - Net is used . Figure shows the background removal of the cardamom plant leaf images using U2 -Net. Figure shows the original cardamom plant leaf images .



Conclusion

In conclusion, the development of a robust and effective method for cardamom plant disease detection is crucial for ensuring the health and productivity of cardamom crops. By harnessing advancements in technology such as machine learning algorithms, image processing techniques, and sensor technologies, researchers and agriculturists can create innovative solutions tailored to the specific needs of cardamom cultivation. Through careful experimentation and validation, these methods can accurately identify and diagnose diseases affecting cardamom plants, enabling timely interventions to mitigate the spread and impact of such diseases. Moreover, the adoption of these technologies can empower farmers with real-time insights, facilitating proactive management practices and ultimately contributing to the sustainability and resilience of cardamom farming communities. As we continue to refine and implement these techniques, collaboration between researchers, industry stakeholders, and farmers will be essential to address the complex challenges facing cardamom cultivation and secure the livelihoods of those dependent on this valuable crop.

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