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Detection of Banana Leaf Disease and its Analysis Using Different Techniques

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Review Article

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ABSTARCT

Banana cultivation is the one of the major agriculture elements in India. As same time common problem of cultivation is that crop has been influenced by way of numerous illnesses. Early disease diagnosis is very important for banana production and crop management. Banana diseases are responsible for loses that directly impact on global fruit production and management system, resulting in economic losses of country. Proposed method combined with modified convolutional neural network and Region-Based segmentation with optimal threshold technique enabled banana disease detection and classification is proposed to overcome these issues and guide the farmers through enabling fertilizer that have to be utilized for avoiding the disease in the initial stage. The purpose of this paper is to introduce various deep learning techniques including convolutional neural network, support vector machine, AlexNet, ResNet-50, artificial neural network and VGG-16. This study has the capacity to motivate the researchers to utilize the article to better understanding of related disease prediction algorithms.

Keywords: Banana; Disease detection; Deep learning; Transfer learning; Region-based multi threshold

INTRODUCTION

Agriculture is the vital resource of fruit for humanity and it is very important sector that decide the economy of our country [1]. Agriculture is the critical source of income of any developing countries. India is the largest country of banana production with 29,124000 tones.

India's banana rank is first in productions. Production is highest in Maharashtra with 3924.1 thousand tones. Followed by Tamil Nadu with 3543.8 thousand tones. Other leading banana producing states are Karnataka, Gujarat,

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Andhra Pradesh and Assam. Banana is the source of many minerals such as vitamin B6, fiber, potassium, magnesium and vitamin C [2]. Banana plant leaves worldwide is affected by many diseases & pest. Early disease diagnosis is very important for banana production and crop management. Banana diseases are responsible for loose that directly impact on global fruit production and management system, resulting in economic losses of country [3]. Banana leaves are large, ranging from 30 to 50 centimeters. The banana leaf refers to the large, flexible, and waterproof leaf of banana plants; it is a commonly used item in various cultures around the world for different purposes. The banana plant is affected by many diseases and sometimes the symptoms are present or visible in the leaf, stem, flower, fruit, roots, and suckers. The major diseases mostly affect the leaf [4].

LITERATURE REVIEW

Types of banana leaf diseases fundamentals

Panama wilt: Panama wilt disease is also known as Fusarium wilt of banana. It is a type of fungal disease that affects banana plant. The existence of panama wilt disease may lead to decrease in the yield of banana plant and the compromise the quality of fruit they produced. The spread of panama wilt disease can be prevented by adopting some appropriate practices like crop-rotation. Additionally, using fungicides can significantly diminish the transmission of the disease [5,6]. At first the lower leaves of banana plant display grey in color as the time pass, the yellow coloration spread toward the center of the leaf, leading to the complete yellowing of the leaf.

Yellow sigatoka: The yellow sigatoka also recognized as the yellow sigatoka leaf spot. It is a notable disease that impacts banana plants. The culprit behind this disease is the fungus *Mycosphaerella musicola*, which was previously referred to as *Mycosphaerella Fijiensis*. The presence of yellow sigatoka disease initially appears as small yellow spots on the leave of banana plants, as the disease advances, the size of yellow spots increase and may eventually come together to form a larger lesion [7]. It is essential to properly spacing banana plants for promoting good air circulation, as this can effectively decrease humidity and restrict the spread of disease.

Black sigatoka: The black sigatoka known as black leaf streak diseases, it is a fungal disease and it predominantly targets banana plant especially the cavendish variety which is recognized as one of the most cultivated banana variety across the globe. The symptoms of black sigatoka, initially the small dark spot appears on the lower leaves of banana plant, as the disease progresses, these spot enlarge and irregularly shaped lesions that are dark brown to black in color. The existing of black leaf spotting on banana yield, firstly it impairs the photosynthetic resign of leaves and decreases the leaf area thereby this has a significant impact on the weight of bunches. secondly it reduced the duration of green life cycle [8].

Bunchy top virus: The development and physically appearances of banana trees are negatively affected by bunchy top virus that is also referred by Banana Bunchy Top Virus (BBTV). If an infected tree manages to produce fruit, the bunch will be undersize and irregular shaped. The virus carries from one plant to others by banana aphids, which acquire the virus while feeding on infected trees and then transmit it to healthy trees. Unfortunately, there is currently no remedy for BBTV, necessitating the removal of any infected tree.

Cucumber mosaic virus: Banana production is greatly affected by various virus-induced diseases. Cucumber mosaic virus is acknowledging one of the most economical destructive viruses that affect financial losses to banana farmers (Figure 1).

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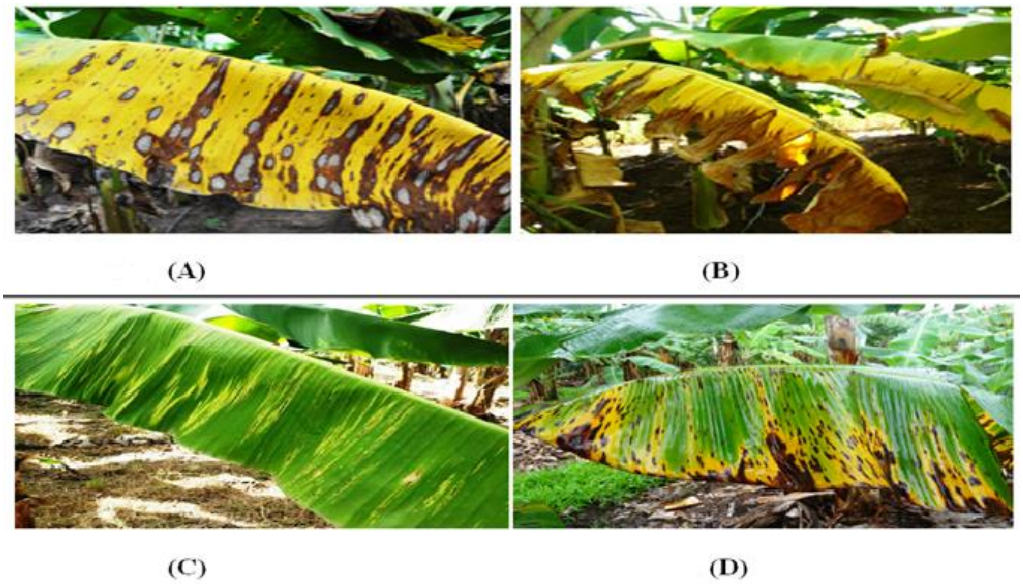

Figure 1. Banana leaf diseases. A. Yellow Sigatoka; B. Panama wilt; C. Cocumber mosaic virus; D. Black sigatoka.

Existing system: The current approach to diseases detection in banana plants relies on professional making visual observations to identify and detect plant illness, this method requiring large team of professionals and continues monitoring, additionally in India. Farmers lack the necessary resources or knowledge to seek the advice from specialists, who may charge high fees and take valuable time. The proposed solution offers a more efficient and cost effective approach to monitor large crop field by automatically diagnosis diseases based on visual cues from banana plant leaves.

Classification techniques

Classification techniques are a set of method used in deep learning and machine learning to categorize image into different classes such as disease affected leaf image and healthy leaf image based on their features. Here are some common classification Techniques

Convolutional Neural Network (CNN): A Convolutional Neural Network (CNN), also recognized as ConvNets, is a specialized deep learning algorithm primarily developed for task object recognition such as image classification, detection and segmentation, CNN stand out traditional machine learning algorithms by their capability to independently extract features on a large scale eliminating the necessity for manual features engineering and thereby improving efficiency. The key components of convolutional neural network are convolutional layer, rectified linear unit, pooling layer and fully connected layer.

Support Vector Machine (SVM): A Support Vector Machine is a robust supervised learning model utilized for classification and regression tasks, SVM aim to identify an optimal boundary in the features space that maximize the margin between different classes, SVM effectively separate classes while maximizing the distance to the nearest examples, this approach is grounded in statistical learning theory, convex optimization problem and structural risk minimization problem. SVM are versatile and can be applied to various domain such as text categorizations, object recognition, image classification and computer vision.

Artificial Neural Network (ANN): Banana plant leaf disease detection greatly benefits from the utilization of artificial neural network, particularly CNNs [9-11]. These advanced technologies are highly effective in the early identification of diseases like sigatoka, which commonly affect banana plants [2]. Unlike labor intensive and time consuming traditional methods that requires expertise and manual effort, CNNs such as BananaSqueezeNet model, enable

accurate diagnosis of various banana leaf diseases with exceptional, precision, recall and specificity. This ultimately lead to a significant improvement in banana production, additionally the integration of machine learning and deep learning techniques with image processing allows for the prompt detection of diseases, minimizing yield losses and empowering farmers to implement preventive measures.

AlexNet: AlexNet is a convolutional neural network that has been employed for the purpose of disease detection in particularly in banana plant [12]. AlexNet, famous for its object detection capabilities in images has been adapted to meet the need of identifying disease in banana plant, this task is challenging due to the diverse range of leaf disease [13]. The modified AlexNet was trained using a dataset obtained by the human annotations, resulting in the creation of advanced plant disease detection system. The system has demonstrated impressive capabilities in identifying diseases in plants. Such an approach facilitates early detection of diseases, allowing farmer too promptly implement preventive actions and reduce crop damage.

(Residual Network) ResNet-50: ResNet-50 is a deep learning model that has been applied in different field like product recommendation system. Plant disease classification and emotional reorganization, it is a widely recognize architecture known for its effectiveness in task like image classification and feature extraction [14]. ResNet-50 is notable for its ability to capture complex pattern and features from image, making it well suited for tasks that require high precision and recall, even when dealing with visually similar element. Furthermore, ResNet-50 incorporates skip connections that assist in reusing learned features, addressing issues like vanishing gradient and enabling training on deeper network for enhanced accuracy. The architecture's efficiency in utilizing computational resources allows it to be deployed on a range of devices, from smartphone to embedded system, making it a versatile option for various applications [15].

(Visual Geometry Group) VGG-16: VGG-16 serves as a deep learning model utilized for the detection of plant diseases through image analysis. It is part of collection of model like VGG-19 and ResNet-50 that has been utilized in this field. Research studies has demonstrated that VGG-16, in combination with VGG-19, has proven to be effective in identifying plant disease, achieving an accuracy level of approximately 86% and a high F-1 score. By using the convolutional neural network and Rectified Linear Unit (ReLU) activation function, the model automatically recognizes and categories plant illness form leaf images, assisting in early and precise disease detection to improve agriculture productivity and reduce pesticide usage (Table 1).

Table 1. Classification techniques.

S.No.	Classification techniques	Advantage	Disadvantage
1	CNNs	High accuracy rate, CNNs has the capability to handle high dimensional data and facility the exchange the information across the layer thereby enhancing the efficiency of data processing.	Implementing CNNs can be challenging due to the constraint of limited computational power and low power consumption requirement in edge application.
2	SVM	The main benefits of SVM are its ability to accurately detect with a 99.6% accuracy rate.	It is important to acknowledge that training SVM on large dataset may require substantial computational resources.
3	ANN	Artificial Neural Network showcase impressive performance in large scale data analysis, as it allow for optimal prediction with lower computational expenses.	Transparency is lacking in the functioning of ANNs, as the solution they arrive at and do not offer any insight into the methods or reasons for their outcomes.

4	Alex Net	AlexNet demonstrates exceptional performance in detecting plant disease surpassing VGG-16 and Lenet-5 in terms of accuracy. It attains a remarkable accuracy rate of 96.76% in the identification of various crop diseases.	AlexNets, deficiency in scalability in plant disease detection is due to its specialization on particular dataset, unlike the more adaptable VGG and ResNet Model that are prevalent in the field.
5	ResNet-50	The accuracy of plant disease classification is significantly improved with ResNet-50 due to its features reuse, reduction of vanishing Gradients problem and support for training on deeper network, outperforming shallower models in terms of accuracy.	ResNet-50 is widely utilized and efficient model. However, its relatively lower parameter count might impose certain limitations on its capability to effectively capture complex features from image. Consequently, this could potentially affect its overall performance in tasks that demand intricate data extraction and analysis.
6	VGG-16	VGG-16 demonstrates superior performance in plant disease detection compared to CNNs and MobileNet achieving accuracy rate of 89%, 92% and 95%, tomato, potato and apple disease respectively.	Enhancing the performance of VGG-16 model require addressing class imbalance problem by ensuring equitable distribution of image across all classes.
Abbreviations: CNN: Convolutional Neural Network; SVM: Support Vector Machine; ANN: Artificial Neural Network; VGG: Visual Geometry Group.			

Segmentation techniques

Segmentation Techniques refer methods used to divide the dataset into distinct segments based on certain characteristics. Segmentation techniques are essential for identifying leaf diseases in banana plant. Numerous research studies have investigated the application of cutting edge technologies to achieve precise and timely disease detection [16].

Adaptive fusion of K-means resign growing: Adaptive Fusion of K-Means Resign Growing is employed for segmenting abnormalities in plant leaves. This method is combines the K-Means Algorithm with region growing to produce precise segmentation outcomes [17]. AFKMRG is utilized to enhance the process of features extraction and improve classification models. Through the integration of AFKMRG, the process of segmentation, classification and features extraction are enhanced, leading to high and precision rates in the multi disease classification of plant leaves.

Region-based convolutional neural network: The detection of plant disease has seen significant promise through the utilization of region-based nonvolution neural network. Numerous studies have put forth innovative approaches to enhance the extraction of features and improve the performance of model [18]. One notable example is the integration of position attention block with transfer learning which has demonstrated improved capabilities in features extraction and achieved high accuracy rate in the detection of wheat diseases [19]. Additionally, the integration of multi-scale mechanism in hybrid model like MSCVT has enabled the fusion of local and global features, resulting in advanced performance in the recognition of crop diseases. This advancement highlights the importance of region-based CNN architecture to the accuracy and efficiency of plant disease detection system.

K-means clustering: A K-Means clustering algorithm is a conventional method used to segment an image into a specified number of clusters based on performance metric. This algorithm tackles the clustering problem by organizing pattern in to clusters where patterns within cluster are more similar to the each other (maximum intra-cluster similarity) than to patterns in other clusters (minimum inter-cluster similarity). The clusters are formed using

the K Means algorithms to minimize the squared Euclidian distance between the cluster center and the patterns (Table 2) [19].

Table 2. Segmentation technique.

S.No.	Segmentation techniques	Advantage	Disadvantage
1	Adaptive Fusion of K-Means Region Growing	The integration of K-Means Region, the segmentation of abnormality in plant leave is greatly improved, leading to a remarkable enhancement in accuracy and precision for multi-disease classification, with rates reaching up to 98.35% and 98.40% .	K-Means Region Growing mandates the Pre-Configuration of initial condition, which result in local optimization and a deficiency in self-adaptive segmentation.
2	Region Growing Fast Peak Detection (RGFPD)	The RGFPD algorithms has demonstrated its superiority over conventional method such as Fuzzy C-means and CNN segmentation technique, it offer several advantages including reduced calculation cost, faster segmentation without the need for presetting initial condition, shorter algorithms running time.	RGFPD might not offer the necessary level of accuracy and specificity for precise identification of plant diseases when compared to specialized deep learning techniques or hyper-spectral imaging techniques.
3	Region-based Convolutional Neural Network	R-CNNs is, known as region-based convolutional neural network provide numerous benefit for plant disease detection, RCNN adopted to develop lightweight model, making them highly efficient utilization in real-time applications.	Processing complete leaf image with R-CNNs can result in high computational overhead and time requirement, impacting performance due to inadequate training data quality.

Banana Leaf disease detection and classification is a problem for very long time many types of studies were accomplished on this field which gave trustworthy effects information of some finding such as given below:

In 2022, K. Lakshmi Narayanan et al., proposed Banana disease detection can be achieved using a hybrid Convolutional Neural Network (CNN) with Functional Support Vector Machine (FSVM) is a hybrid of binary and multiclass Support Vector Machine (SVM), and the classification is proposed to guide farmers on how to use fertilizers to prevent disease in the early stages to overcome these issues. The proposed technique has a 99% accuracy rate when compared to other deep learning techniques [1].

In 2019, Michael Gomez Selvaraj et al., proposed method of using deep transfer learning was explored to automatically detect banana pest and disease symptoms on different parts on banana plant using real time field image. The Experiment outcome carried out accuracy between 70 to 99% of the different model examined. The strong model developed from this study could be more beneficial to expand the decision support system to assist early identification of pest, illnesses and their control [3].

In 2023, Chetan H R and colleagues introduced a method for identification and classification through image processing and Resnet5, aiming to reduce the losses and enhance the crop quality the proposed of Image processing is to eliminate any noise present in the image by converting the RGB Input to an HSV image. The performance of the proposed model was assessed by comparing its result obtained with those of others classifier. The proposed model demonstrated higher accuracy when compare to other classifier algorithms [5].

In 2022, T. Mahendran and Seetharaman proposed studies introduced a novel approach for Leaf disease detection and classification especially in banana plant, features extraction is done by using GLCM Techniques and disease classified using deep convolutional neural network, the suggested strategy has been implemented to support farmers

in accurately identifying diseases and detecting them at an early stage, thereby preventing their spread to adjacent plants [6].

The proposed system by N. Saranya and their colleagues in 2020, this technique encompasses various stages including image acquisition, image pre-processing, feature extraction, disease detection and classification of diseases through an Artificial Neural Network, within the proposed system, the fuzzy c-means is used to separate the picture and the histogram is to transform the image with none lack of information within the banana plant, this paper proposed higher classification and system is used to provide the huge quantity of the banana production [8].

Ramachandran Sangeetha et al., proposed advance deep learning model to enhance the detection of panama wilt disease in banana leaves [20]. The main aim of this study is to examine color change data in banana leaves through the utilization of convolutional neural network. Initially, the convolutional neural network will be employed to examine the banana leaf images and detect any possible indications of the diseases. This method under consideration achieved an accuracy of 91.56%, a precision of 91.61%, a recall of 88.56%, and F-1 score 81.56%. It surpasses of privies method in terms of accuracy, precision, recall and F-score.

The study by Ahmad waleed Salehi et al., provide a comprehensive overview of convolutional neural network and Transfer Learning in medical imaging, transfer learning, particularly when fine-tuning pre-trained CNNs model has shown promise in improving accuracy and efficiency in image classification task, especially in scenario with limited labeled data [21].

Amatullah Fatwimah Humairaa Mahomodally et al., Discus in proposed study evaluates VGG-16 and VGG-19 models as more efficient for plant disease detection compared to ResNet-50 and ResNet-101 achieving higher accuracy and F-1 score, The ResNet-50 and ResNet-101 show lower efficiency and accuracy [22]. Deep learning approach evaluated for plant disease detection. The VGG-16 and VGG-19 models achieved accuracy approximately 86% and F1-score of 87%.

DISCUSSION

Our proposed work primarily consists of five phases

Image acquisition, image preprocessing, image segmentation, feature extraction, and disease identification. We collected images of banana plant leaves by visiting farms and gathering images from a village dataset [3]. Due to variations in size, shape, and noise content, preprocessing is conducted to reduce noise. The preprocessed images are then segmented using region based segmentation with optimal threshold technique to isolate the areas of interest within the input image. Features are extracted from the segmented regions of the image, which are subsequently utilized for disease classification. The method of proposed work is illustrated in Figure 2.

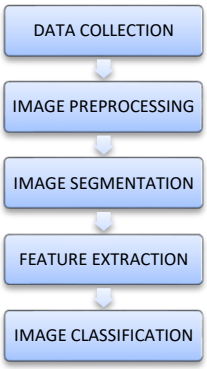

Figure 2. Banana leaf diseases detection process flow chart.

Data collection: The data set of proposed study includes about 1000 of images of banana plant leaf, both healthy and diseased. These photos were taken from different field in central India district of Madhya Pradesh and Maharashtra. The images were collected in various resolutions capturing using mobile with good resolution using VGA camera and digital camera.

Image preprocessing: To improve the quality of acquired images for the upcoming steps, image preprocessing is applied. The default data in the image is not altered by this process. It resizes images and applies some helpful filters to find the disease information on the banana leaf. Image resizing is required because the image that was taken and saved as a data set has different resolutions. It needs to be changed to a standard fixed resolution size (M*N). Other noises in the images are eliminated by applying image filtering techniques like the median filter.

Image segmentation: Segmentation involves the separation of the region of interest from the remaining parts of the image. The Region Based Image Segmentation is employed to distinguish the infected section of the leaf from the healthy portion [24-30].

Feature extraction: The process of automatically identifying and extracting pertinent features from unprocessed input data is known as feature extraction. Feature extraction is based on the idea that we can let the neural network learn the most relevant features directly from the data during training, as opposed to manually engineering features, which can be laborious and domain-specific. This eliminates the need for manual feature engineering or in-depth domain knowledge and enables us to perform better on challenging tasks like speech or picture recognition [31,32].

Image classification: A key task in computer vision and deep learning is image classification, which involves teaching a computer system to automatically recognize and classify visual images into predefined classes or labels. Modified Convolutional Neural Networks (CNNs), in particular, are deep learning algorithms that are frequently used for this kind of task because of their capacity to extract complex patterns and features straight from the unprocessed image data [33,34].

CONCLUSION

Agriculture is very important for producing fruit and food for country and play important role in growth economy of our country so it is need proper management of agriculture product is very important and it's necessary to prevent banana from harmful disease such as black and yellow sigatoka, cucumber mosaic virus and panama wilt etc. In this research produce deep learning based solution has been proposed for detecting and classify the banana disease by investigating the banana leaf. In the proposed model using modified convolutional neural network and region-based segmentation with optimal threshold technique to detect banana leaf diseases and allowing for quick and respective action to prevent further spread of disease, in this proposed deep learning model set of image data of banana are collected and processed, the following activities enables the analysis of various image data from the crop period to harvest period of Banana. The performance of the algorithms is measure or evaluated using F-1 score, precision, recall and accuracy.

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