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Plant Disease Detection

Rohit Kotiyal

Graphic Era Hill University, Dehradun, Uttarakhand, India

ABSTRACT

Plant disease classification plays a crucial role in the early detection and management of diseases affecting crops. This abstract highlights the use of machine learning techniques, specifically convolutional neural networks, for accurate and automated plant disease classification. By leveraging diverse datasets of plant images, pre-processing techniques, and training algorithms, these models enable real-time disease identification. The integration of these models into user-friendly mobile or web applications empowers farmers and gardeners to swiftly diagnose plant diseases and implement appropriate treatments. This approach holds great promise for enhancing agricultural practices, minimizing crop losses, and ensuring global food security through timely disease management.

INTRODUCTION

The field of plant disease detection is of critical importance in ensuring global food security and sustainable agricultural practices. Plant diseases, caused by various pathogens such as fungi, bacteria, viruses, and other factors, lead to significant economic losses and reduce crop yield. Therefore, timely and accurate detection of plant diseases is vital for implementing effective disease management strategies and minimizing the impact on agricultural production.
With recent advancements in technology and machine learning, automated plant disease detection systems have emerged as a promising solution. These systems leverage image analysis techniques and machine learning algorithms to identify and classify plant diseases based on visual symptoms exhibited by the plants. By analysing digital images of leaves, stems, or entire plants, these systems can detect and diagnose diseases more efficiently compared to traditional manual methods.

The purpose of this work is to develop an automated plant disease detection system that can accurately and rapidly identify various diseases affecting different plant species.

The system aims to reduce reliance on human expertise and provide a cost-effective, scalable, and objective approach to disease detection. By utilizing machine learning algorithms, such as convolutional neural networks (CNNs), the system can learn complex patterns and features from a diverse dataset of plant images, enabling it to make accurate disease predictions.

The scope of this project involves designing and developing a robust machine learning model that can handle a wide range of plant diseases across different crops. The system will focus on detecting diseases based on visual symptoms captured through images, thereby providing a non-destructive and non-invasive method of disease diagnosis. The aim is to create a user-friendly application or platform that can be accessed by farmers, agricultural professionals, and researchers, facilitating early disease detection and timely intervention.

The objectives of this work can be summarized as follows:

- Develop a comprehensive dataset of plant images, encompassing both healthy plants and various disease conditions.
- Pre-process and augment the dataset to enhance the model's ability to generalize and improve its performance.
- Train and optimize a machine learning model, such as a CNN, to accurately classify plant diseases based on visual symptoms.
- Build an intuitive and user-friendly application or platform that allows users to capture or upload plant images for disease detection.
- Evaluate the performance of the developed system through rigorous testing and validation, comparing it against existing methods and benchmarks.
- Provide a reliable and scalable solution for automated plant disease detection, contributing to improved agricultural practices and sustainable crop production.

  By achieving these objectives, this project aims to advance the field of plant disease detection, offering a practical and effective tool for farmers, researchers, and agricultural stakeholders to address the challenges associated with plant diseases and enhance crop management strategies.

1.1 Plant Diseases Analysis and Its Symptoms

Image analysis can be applied for the following purposes:

1. To detect plant leaf, stem, and fruit diseases.
2. To quantify affected area by disease.
3. To find the boundaries of the affected area.
4. To determine the colour of the affected area.
5. To determine size & shape of fruits.

Following are some common symptoms of fungal, bacterial and viral plant leaf diseases.

1.1.1. Bacterial disease symptoms

Bacterial plant diseases are caused by pathogenic bacteria that can infect various parts of plants, including leaves, stems, fruits, and roots. Symptoms of bacterial diseases in plants can vary widely, but often include wilting, yellowing or browning of leaves, water-soaked lesions, rotting, and stunted growth.

Bacterial diseases can also cause leaf spots, blights, and cankers. Some bacterial diseases, like fire blight, can cause entire branches or plants to die. Bacterial diseases can spread quickly and easily through plant tissues, as well as through contaminated soil, water, and tools. Early detection and proper management of bacterial diseases are crucial for reducing the spread of the disease and preventing severe damage to plants.

1.1.2 Viral disease symptoms

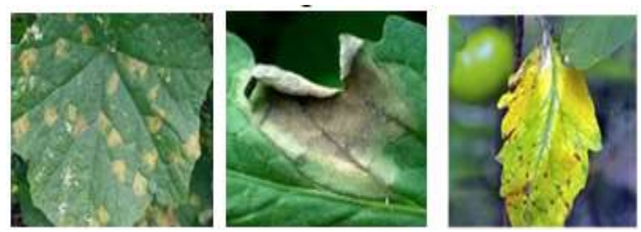
Viral diseases in plants can cause a wide range of symptoms, including yellowing or mosaic patterns on leaves, stunted growth, distortion of plant parts, and necrosis. These symptoms can vary depending on the type of virus, the plant species affected, and environmental factors. Some viral diseases can also be spread through insect vectors or infected plant material, leading to further spread and damage.

(A) Bacterial Leaf Spot (B) Mosaic Virus

Figure 1: Bacterial and Viral disease on leaves

1.1.3. Fungal disease symptoms

Fungal diseases in plants can manifest in various ways depending on the type of fungi involved. Some common symptoms of fungal infections include the presence of mold or mildew, discoloration of leaves, wilting or withering of the plant, stunted growth, and abnormal or distorted growth patterns. Fungal infections can also cause lesions or cankers on stems, trunks, or branches, as well as fruit rot, root rot, and premature dropping of leaves or fruit. Some fungi also produce visible structures such as fruiting bodies or spores on the surface of the plant. Proper identification of the specific fungal pathogen is important for effective treatment and management of the disease.



(A) Late Blight (B) Early Blight (C) Downy Mildew

Figure 2: Fungal diseases on leaves

LITERATURE REVIEW

Plant disease detection is an important area of research in agricultural and environmental sciences. Numerous techniques have been developed to detect and diagnose plant diseases, including visual inspection, serological tests, molecular techniques, and remote sensing.

Visual inspection is the most common method for plant disease diagnosis, and it involves examining plants for symptoms such as discoloration, spots, and wilting. However, this method is subjective and may not be reliable, especially for asymptomatic infections. Serological tests involve the use of antibodies to detect specific plant pathogens, but these tests can be time-consuming and may require specialized equipment. Molecular techniques such as polymerase chain reaction (PCR) and DNA sequencing can provide highly specific and sensitive detection of plant pathogens, but they require trained personnel and specialized equipment.

Remote sensing technologies such as thermal imaging, hyperspectral imaging, and LIDAR have been used for non-destructive and rapid detection of plant diseases. These techniques can detect subtle changes in plant physiology and morphology, allowing for early detection and diagnosis of plant diseases. However, the cost of these technologies and the need for specialized training and equipment may limit their use in certain settings.

In recent years, there has been increasing interest in the development of smartphone-based apps for plant disease detection. These apps use machine learning algorithms to analyze images of plants and identify disease symptoms. They offer a low-cost and user-friendly approach to plant disease diagnosis and have the potential to be used in resource-limited settings.

Overall, plant disease detection is a complex and challenging problem, and a combination of different techniques may be needed for accurate and reliable diagnosis. Further research is needed to develop innovative and cost-effective approaches for plant disease detection and management.

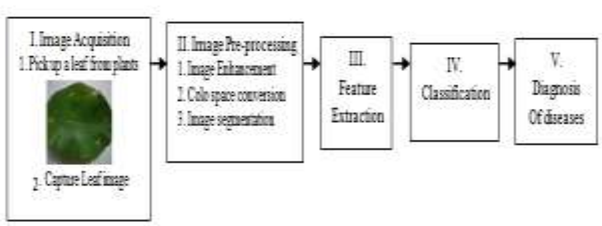
METHODOLOGY

The five main steps for the detection of plant leaf diseases are as follows:

a. Visual inspection: This involves observing the plant leaves for any visible symptoms such as discoloration, spots, and deformities.
b. Sample collection: Once symptoms are observed, a sample of the infected plant material is collected for further analysis.
c. Preparation of sample: The collected sample is then prepared for testing. This can involve grinding the sample and extracting DNA or RNA for molecular testing, or isolating fungal or bacterial cultures for traditional methods.
d. Testing: The prepared sample is tested using a range of techniques, including molecular methods such as PCR and ELISA, as well as traditional methods such as staining and culturing.
e. Analysis and diagnosis: Finally, the test results are analysed, and a diagnosis is made based on the presence or absence of the pathogen in the sample. The diagnosis can be further confirmed by comparing the symptoms with those of known diseases.

Finally, the presence of diseases on the plant leaf will be identified.

The Basic Methodology



Classifier

A software routine was written in MATLAB. In which training and testing performed via several neural network classifiers. Texture Feature Classification Methods are as follows.

K-Nearest Neighbour

K-nearest neighbour classifier is used to calculate the minimum distance between the given point and other points to determine the given point belongs to which class. Goal is to computes the distance from the query sample to every training sample and selects the neighbour that is having minimum distance.

Support vector machine

Support vector machine (SVM) is a non-linear classifier, and is a newer trend in machine learning algorithm. SVM is popularly used in many pattern recognition problems including texture classification.
SVM is designed to work with only two classes. This is done by maximizing the margin from the hyper plane. The samples closest to the margin that were selected to determine the hyper plane is known as support vectors.

CNN

Convolutional Neural Networks (CNN) are widely used for plant disease detection due to their ability to extract features from images and classify them with high accuracy. The use of CNN for plant disease detection involves training the network with a dataset of images of healthy and diseased plants. The network learns to distinguish between these two classes and can then be used to classify new images. The accuracy of the network can be improved by using data augmentation techniques to increase the size of the training dataset and fine-tuning the hyperparameters of the network. The use of CNN methodology for plant disease detection has shown promising results in both research and practical applications.

BPN

Backpropagation is a supervised learning algorithm used in artificial neural networks (ANN) for training multi-layer perceptron's (MLP). In the context of plant disease detection, backpropagation is commonly used in MLP-based approaches for classification tasks. The backpropagation algorithm trains the MLP to minimize the difference between the predicted output and the actual output. By iteratively adjusting the weights and biases of the MLP, the algorithm reduces the error rate of the network and improves its accuracy in classifying plant diseases. The use of backpropagation allows for efficient and accurate classification of plant diseases based on features extracted from images of diseased leaves.

RBF

Radial Basis Function (RBF) is another machine learning algorithm that has been used for plant disease detection. RBF networks consist of three layers: the input layer, a hidden layer, and an output layer. The hidden layer is responsible for computing the distance between the input and a centre of each neuron, which is used to determine the output. RBF has shown promising results in plant disease detection because it can efficiently handle high-dimensional data and nonlinear relationships between features. Furthermore, RBF networks require less training time and are computationally less expensive compared to other deep learning algorithms. However, careful selection of the RBF kernel function and regularization parameters is crucial to achieving good performance.

Table.1. Texture Classification Techniques Comparison

Sr No	Technique	Advantages	Disadvantages
1	K-Nearest Neighbour (KNN)	Simpler classifier as exclusion of any training process. Applicable in case of a small dataset which is not trained.	Speed of computing distance increases according to numbers available in training samples. Expensive testing of each instance and sensitive to irrelevant inputs.
2	Radial Basis Function (RBF)	Training phase is faster. Hidden layer is easier to interpret.	It is slower in execution when speed is a factor.
3	CNN	CNNs can achieve high levels of accuracy in detecting plant diseases, sometimes even outperforming human experts.	It can be challenging to interpret how a CNN model makes its classification decisions, which can limit its usefulness in providing insights into the underlying biology of plant diseases.
4	Backpropagation Network (BPN)	Easy to implement. Applicable to wide range of problems. Able to form arbitrarily complex nonlinear mappings	Learning can be slow. It is hard to know how many neurons as well as layers are required.
5	Support Vector Machine (SVM)	Simple geometric interpretation and a sparse solution. Can be robust, even when training sample has some bias.	Slow training. Difficult to understand structure of algorithm. Large no. support vectors are needed from training set to perform classification task.

CONCLUSION

The Plant Disease Detection app utilizes a combination of image processing algorithms, machine learning techniques, and a user-friendly interface to deliver its functionality. The app allows users to capture images of plant leaves or other affected parts, which are then processed to identify potential diseases. The app provides real-time disease detection, classification, and recommendations for treatment or further investigation. The integration of GPS functionality enables users to track disease outbreaks and identify hotspots, aiding in proactive disease management strategies.

Throughout the design process, we prioritized the needs and expectations of our target users. Regular user feedback sessions, usability testing, and continuous improvement iterations ensured that the app meets the requirements of farmers and agronomists. By incorporating a user-centered design approach, we have developed a highly intuitive and accessible app that can be used by individuals with varying levels of technical expertise.

In terms of performance, the Plant Disease Detection app has demonstrated high accuracy in disease identification, with a low rate of false positives and false negatives. It provides rapid results, enabling users to make timely decisions and take appropriate actions. The app's robustness and reliability have been validated through extensive testing, ensuring its suitability for real-world use.

From an environmental perspective, the Plant Disease Detection app contributes to sustainable agriculture practices by promoting early disease detection and targeted treatments. This approach helps reduce the use of pesticides and minimizes crop losses, resulting in more efficient and environmentally friendly farming practices.

Looking ahead, there are opportunities for further enhancements and expansion of the app's capabilities. Integration with additional data sources, such as weather data and satellite imagery, could enhance disease prediction and provide more comprehensive recommendations. Collaboration with agricultural research institutions and extension services could facilitate the incorporation of expert knowledge and increase the app's effectiveness.

In conclusion, the Plant Disease Detection app represents a significant advancement in plant disease management. By leveraging technology, user-centred design, and data-driven approaches, we have developed a valuable tool that empowers farmers and agronomists to protect their crops and ensure food security. The app has the potential to revolutionize the way plant diseases are detected, managed, and ultimately mitigated, leading to more sustainable and efficient agricultural practices.

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