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”PLANT DISEASES DETECTION”

ABSTRACT

Early and accurate detection of plant diseases is essential for enhancing crop productivity and ensuring food security. This research presents an intelligent plant disease detection system that integrates Convolutional Neural Networks (CNNs) with IoT-based sensors to identify and monitor plant health in real time. Leveraging deep learning, the system is trained on large datasets of diseased and healthy leaf images to classify various plant conditions with high accuracy. Additionally, the use of IoT devices enables the collection of environmental data such as temperature and humidity, further supporting disease prediction. The final solution is deployed as a mobile application, providing farmers and agricultural professionals with a user-friendly tool for early diagnosis and decision-making. This work demonstrates the potential of AI and smart technology in revolutionizing precision agriculture, reducing crop loss, and promoting sustainable farming practices. Plant disease detection has become an increasingly vital field in agriculture due to the growing need to protect crops from pests, pathogens, and environmental stressors that can severely impact yield and food quality. With the global population rising and the demand for food intensifying, early and accurate identification of plant diseases is crucial for ensuring sustainable agricultural practices and food security. Traditionally, disease detection has relied on manual observation by trained agricultural experts, a method that is not only labor-intensive and time-consuming but also prone to human error and inconsistency. These limitations have driven the development of automated approaches using advanced technologies such as image processing, machine learning (ML), and deep learning (DL). Image-based plant disease detection involves capturing photos of leaves or plant parts using digital devices, followed by analysis through computer vision algorithms. These algorithms can detect disease symptoms such as lesions, spots, or discoloration, which are then used to classify the specific disease affecting the plant. Among these, deep learning techniques—particularly Convolutional Neural Networks (CNNs)—have proven to be highly effective due to their ability to learn complex patterns and features from large datasets without the need for manual feature extraction. These models are trained on extensive image datasets like PlantVillage, which contains thousands of annotated images of various crops and diseases. Once trained, CNNs can achieve high accuracy in classifying multiple types of plant diseases and can be deployed in real-world scenarios via smartphone applications, drones, or IoT devices for real-time field monitoring. Such tools empower farmers with immediate diagnostic information and recommendations, enabling timely interventions that can prevent disease spread and reduce crop loss. However, challenges remain, such as the need for large, diverse datasets, the risk of model overfitting, and performance variability under different environmental conditions like lighting and background clutter. To overcome these issues, researchers are exploring solutions such as transfer learning, data augmentation, and the use of multispectral or hyperspectral imaging, which can detect symptoms invisible to the naked eye. As these technologies evolve, plant disease detection systems are becoming more accessible, robust, and integrated into the broader ecosystem of precision agriculture, offering a promising path toward smarter, more efficient farming practices that reduce reliance on chemical treatments and promote environmental sustainabilit

Top of Form

Bottom of Form

INTRODUCTION

Agriculture plays a crucial role in the global economy and food supply, with plant health being a key factor in ensuring high crop yields and sustainability. One of the major challenges faced by farmers worldwide is the early and accurate detection of plant diseases. These diseases, if not identified and treated promptly, can lead to significant crop losses, economic damage, and food insecurity.

Traditional methods of disease detection, which rely on manual inspection by experts, are often time-consuming, labor-intensive, and prone to human error. Furthermore, in rural and under-resourced regions, access to expert knowledge may be limited, making timely diagnosis even more difficult.

With the rapid advancement of technology, particularly in the fields of Artificial Intelligence (AI) and the Internet of Things (IoT), there is a growing opportunity to address this challenge in innovative ways. Deep learning, a subset of AI, has shown remarkable success in image classification tasks and can be effectively used to identify plant diseases by analyzing visual symptoms on leaves. Meanwhile, IoT-based sensors can collect real-time environmental data, such as temperature and humidity, which are often critical factors in the spread and development of plant diseases.

This research proposes an integrated system that combines Convolutional Neural Networks (CNNs) for disease detection with IoT sensors for environmental monitoring. The system is further deployed as a mobile application, making it accessible and practical for farmers in the field. By automating the detection process and enabling real-time monitoring, the proposed solution aims to support more informed decision-making, reduce the reliance on expert intervention, and ultimately contribute to smarter and more sustainable agricultural practices.

PROBLEM STATEMENT

Plant diseases are a major threat to agricultural productivity and food security worldwide. Accurate and timely diagnosis of these diseases is critical to prevent their spread and reduce crop losses. However, traditional detection methods rely heavily on manual inspection by agricultural experts, which can be time-consuming, inconsistent, and inaccessible—especially for farmers in rural or under-resourced areas. Furthermore, early symptoms of plant diseases often resemble one another or may be too subtle to be identified without advanced tools, making early detection even more difficult.

In recent years, image-based disease detection using deep learning has shown promise. However, many existing models struggle to maintain accuracy under real-world conditions, such as variable lighting, diverse backgrounds, and low-resolution images typically captured on mobile devices. In addition, most solutions do not consider environmental factors like temperature and humidity, which are essential for understanding the context of disease development.

Therefore, there is a need for a smart, accurate, and accessible system that can:

\* Identify plant diseases from leaf images using deep learning,

\* Integrate real-time environmental data using IoT sensors,

\* And deliver results through a mobile application that is easy for farmers to use.

This project addresses these gaps by developing an AI-driven, IoT-enabled plant disease detection system that empowers farmers with real- time insights and decision-making support.

OBJECTIVES

The main goal of this project is to develop an intelligent plant disease detection system that assists farmers and agricultural experts in accurately identifying diseases and making timely interventions. To achieve this, the project is guided by the following specific objectives:

1. Detect Plant Diseases from Leaf Images Using Deep Learning

Leverage Convolutional Neural Networks (CNNs) to train a model that can automatically recognize and classify diseases from images of plant leaves.

Ensure the model can differentiate between healthy and diseased leaves, even under challenging conditions like poor lighting, varied angles, or natural backgrounds.

2. Integrate IoT Sensors for Real-Time Environmental Monitoring

Deploy IoT-based sensors in the field to collect real-time data such as:

\* Temperature

\* Humidity

\* Soil moisture (if applicable)

\* Use this data to supplement disease prediction and improve the context-awareness of the system.

3. Develop a Mobile Application for Farmers

Create a user-friendly mobile app where users can:

\* Upload or capture plant leaf images

\* View disease detection results instantly

\* Access environmental sensor readings

\* Receive suggestions for disease control or prevention

4. Train and Test the Model Using a Diverse Dataset

Use publicly available datasets (e.g., PlantVillage) or create a custom dataset with real-time field images.

Split data into training, validation, and testing sets to ensure robust model performance.

5. Evaluate the System’s Accuracy and Real-World Applicability

Test the model under real-world conditions to assess:

\* Accuracy

\* Precision & recall

\* Speed of detection

Validate how well the system performs with mobile images and live sensor data.

6. Support Decision-Making in Precision Agriculture

Provide actionable insights based on detection results.

Help users take preventive or corrective measures quickly, thereby improving crop health and agricultural productivity.

METHODOLOGY

The methodology for this project is designed to develop a complete and intelligent plant disease detection system that combines deep learning with IoT-based environmental monitoring and a mobile application interface. The process is divided into several key phases:

1. Data Collection

Image Data: Use an existing dataset such as PlantVillage, which contains thousands of labeled images of healthy and diseased plant leaves.

Environmental Data: Deploy IoT sensors (e.g., DHT11, DHT22, or BME280) in the agricultural field to gather real-time temperature and humidity data, which are key environmental factors in disease development.

2. Image Preprocessing

Resize all leaf images to a consistent input size (e.g., 224x224 pixels).

\* Normalize pixel values for better neural network performance.

\* Apply data augmentation (rotation, flipping, scaling) to increase dataset diversity and reduce overfitting.

3. Model Selection and Training

Use a Convolutional Neural Network (CNN) for image classification.

Test different architectures such as:

\* EfficientNet

\* MobileNet

\* ResNet

Train the model using the preprocessed dataset:

\* Split into training, validation, and test sets

\* Use performance metrics like accuracy, precision, recall, and F1-score to evaluate

4. IoT Integration

Set up IoT sensors to continuously capture:

\* Temperature

\* Humidity

\* Use ESP32 or Arduino boards to connect sensors and transmit data wirelessly.

\* Data is sent to a cloud service or directly to the mobile app via Wi-Fi/Bluetooth.

5. Mobile App Development

Develop the app using Flutter or React Native.

App features:

\* Capture or upload leaf images

\* View disease prediction results from the CNN model

\* View real-time sensor data (temperature, humidity)

\* Get suggestions or alerts based on disease type

6. Testing and Validation

\* Test the system in real-world conditions using smartphone images and field sensor data.

\* Compare the prediction results with expert/manual assessments.

Evaluate:

\* Model’s real-time accuracy

\* App performance and usability

\* Sensor reliability

7. Deployment

\* Deploy the model in the cloud (or on-device if optimized).

\* Ensure the mobile app syncs predictions with real-time IoT sensor data.

\* Optimize for low-latency responses and offline usage if needed.

CONCLUSION

The project on **Plant Disease Detection** presents an innovative and technologically advanced approach to modern agriculture, combining **Artificial Intelligence (AI)**, **Computer Vision**, **IoT**, and **Remote Sensing** to address the challenges of early and accurate plant disease identification. Traditional methods of manual inspection are increasingly inadequate due to their time-consuming nature and subjectivity, especially in large-scale agricultural settings.

By leveraging **deep learning models such as Convolutional Neural Networks (CNNs)**, the system can classify plant diseases with high accuracy using image data. Integration of **IoT sensors** and **drones** enables real-time environmental monitoring and large-scale crop surveillance, enhancing the system's predictive capabilities. Furthermore, the development of a **mobile application** ensures that the technology is **accessible and user-friendly for farmers**, empowering them with instant disease diagnosis and treatment recommendations.

This comprehensive and scalable solution not only improves **agricultural productivity and sustainability** but also supports small-scale farmers by providing a **cost-effective, efficient, and accurate tool** for disease management. The project lays a strong foundation for future research and deployment of AI-driven tools in **precision agriculture**.