

## AI-Based Crop Disease Detection and Automated Fertilizer Spraying System

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### ABSTRACT

*Agriculture plays a crucial role in ensuring food security and economic stability, especially in developing countries like India. However, crop diseases significantly affect agricultural productivity by reducing both yield and quality. Early detection of plant diseases and timely application of fertilizers are essential to minimize losses and improve farming efficiency. Traditional methods of disease identification depend on manual inspection, which is time-consuming, labor-intensive, and often prone to human error. This project presents an AI-Based Crop Disease Detection and Automated Fertilizer Spraying System designed to support smart agriculture practices. The system uses artificial intelligence techniques to detect crop diseases at an early stage by analyzing plant leaf images using a pre-trained machine learning model. The detection results are processed*

*externally and transmitted to the system through an IoT platform. The NodeMCU ESP8266 acts as the central control unit, receiving disease information and executing decision-making logic. Based on the detected disease condition, the system automatically activates a relay module to control a water pump for spraying the required fertilizer. This automation reduces manual intervention and ensures accurate and timely fertilizer application. Overall, the proposed system provides a cost-effective, reliable, and scalable solution for modern agriculture by integrating artificial intelligence with IoT and embedded systems, thereby improving crop productivity and supporting sustainable farming practices.*

**KEYWORDS:** *Artificial Intelligence, Machine Learning, NodeMCU ESP8266, Crop Disease Detection, Automated*

*Fertilizer Spraying, Relay Control, Smart Agriculture, Precision Farming, Image Datasets.*

## INTRODUCTION

Agriculture is essential for food security and economic growth, but crop diseases significantly reduce yield and quality, making early detection very important. Traditional manual inspection methods are slow, labor-intensive, and often inaccurate, leading to delayed treatment and excessive use of chemicals.

To overcome these issues, the proposed AI-Based Crop Disease Detection and Automated Fertilizer Spraying System integrates artificial intelligence, image processing, and IoT technology for smart farming. Crop leaf images are analyzed using a trained AI model to detect diseases accurately, and the results are sent to the NodeMCU ESP8266, which controls a relay and water pump for automatic fertilizer spraying. This system improves productivity, reduces human effort, minimizes chemical usage, and supports sustainable and efficient agricultural practices.

## RELATED WORK

Recent research in smart agriculture has focused on integrating IoT and artificial intelligence for early crop disease detection

and precision farming. Several studies have proposed CNN-based models to analyze leaf images for identifying plant diseases with high accuracy.

IoT-enabled systems use sensors such as temperature, humidity, soil moisture, and gas sensors to monitor crop conditions in real time. Some works also combine disease detection with automated fertilizer and pesticide spraying to improve efficiency and reduce manual intervention.

## LITERATURE REVIEW

Recent literature in smart agriculture shows significant progress in using AI, image processing, and IoT for crop disease detection and precision farming. Early approaches used traditional machine learning methods such as SVM, KNN, and neural networks with manual feature extraction, which were less accurate and required high preprocessing effort. Later studies introduced CNN and transfer learning models, achieving higher accuracy and better scalability across multiple crops. Researchers also integrated IoT systems for real-time monitoring and automation in farming activities.

However, most existing systems focus only on disease detection, highlighting the need for integrated solutions that combine AI-based detection with automated fertilizer spraying.

## EXISTING METHOD

In existing agricultural systems, crop disease detection is mainly performed through manual inspection by farmers or agricultural experts based on visual observation. Some systems use traditional image processing and machine learning algorithms such as SVM, KNN, and ANN, which depend heavily on manual feature extraction like color, texture, and shape. IoT-based systems are also used to monitor environmental parameters such as temperature, humidity, and soil moisture, but they do not directly identify crop diseases. Fertilizer application is mostly done manually without proper automation or real-time decision support, leading to inefficiency, delayed treatment, and excessive chemical usage in farming practices.

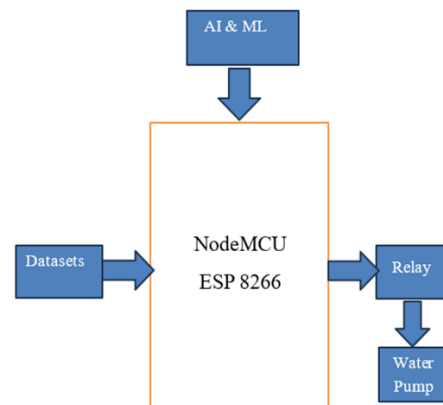
## PROPOSED METHOD

The proposed system integrates artificial intelligence, IoT, and embedded control to automate crop disease detection and fertilizer spraying.

A pre-trained AI model analyzes crop leaf images to identify diseases accurately, and the results are transmitted to the NodeMCU ESP8266 through an IoT platform. The NodeMCU processes the data and applies decision logic to determine the required fertilizer action. Based on predefined

agricultural guidelines, a relay module activates a water pump to spray the appropriate fertilizer automatically. This system enables early disease detection, reduces manual effort, ensures precise fertilizer usage, and improves overall agricultural productivity and sustainability.

## SYSTEM ARCHITECTURE



**Fig 1: Block Diagram**

## METHODOLOGY DESCRIPTION

### SOFTWARE AND HARDWARE COMPONENTS

#### Hardware Components

##### Node-MCU ESP8266



**Fig 2: Node-MCU ESP8266**

Node-MCU ESP8266 is the main microcontroller used in the system for processing and controlling operations. It supports Wi-Fi connectivity, enabling IoT-based communication between AI output and hardware actions.

**Relay Module**



**Fig 3: Relay Module**

The relay module acts as an electronic switch that controls high-power devices using low-power signals from NodeMCU. It is used to safely operate the water pump based on disease detection results.

**Fertilizer Tank**

The fertilizer tank is used to store the required liquid fertilizer or chemical solution. It supplies fertilizer to the pump system for controlled and automated spraying on crops.

**Water Pump**



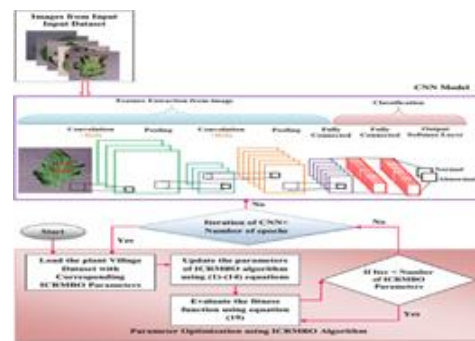
**Fig 4: Water Pump**

The water pump is responsible for spraying fertilizer onto the crop field. It is activated automatically through the relay module to ensure precise and timely application.

**Software Requirement**

The system uses Python for developing and training the AI and machine learning model used in crop disease detection. Artificial intelligence and image processing techniques are applied to analyze crop leaf images and classify disease conditions accurately. Arduino IDE and Embedded C are used for programming the NodeMCU ESP8266 to control the relay and water pump, while enabling smooth IoT communication and real-time system automation.

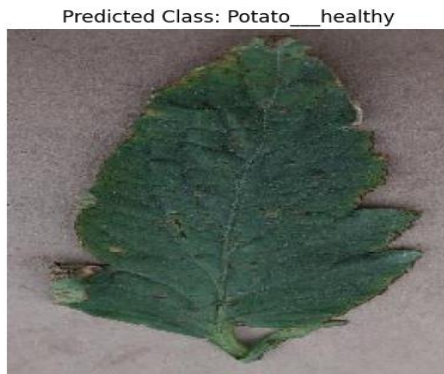
**RESULTS AND DISCUSSION**



**Fig 5: Architecture Of Software**

Machine Learning is a technique that enables systems to learn patterns from data and make predictions without explicit programming. In this project, machine learning is used to detect crop diseases by analyzing leaf images and classifying them

into healthy or diseased categories. The system follows a learning and inference process where a CNN model is trained using labeled datasets and later used for prediction on new images.



**Fig 6: Healthy Leaf**

Deep Learning, especially Convolutional Neural Networks (CNN), is used because it provides high accuracy in image-based classification tasks by automatically extracting important features such as color, texture, and shape. Image processing techniques such as resizing, normalization, and feature enhancement are applied to improve input quality before feeding data into the model.



**2. Early Blight**

**Fig 7: Disease Detection**

Python is used as the main programming language due to its strong support for AI, ML, and image processing libraries like TensorFlow, Keras, OpenCV, and NumPy.

Arduino IDE and Embedded C are used for hardware programming of NodeMCU ESP8266, enabling communication between AI output and physical components like relay and water pump. Together, these technologies create an efficient and automated smart agriculture system.

## CONCLUSION

The AI-Based Crop Disease Detection and Automated Fertilizer Spraying System effectively combines machine learning and IoT to improve modern agricultural practices. It enables accurate disease detection using CNN and ensures timely fertilizer spraying through automated control mechanisms. Overall, the system enhances crop productivity while reducing manual effort and supporting smart farming.

## FUTURE SCOPE

The system can be further improved by expanding the dataset to include more crop types and diseases for higher accuracy. Integration with mobile applications, cloud platforms, and advanced deep learning models can enhance real-time monitoring

and performance. Additionally, the use of drones and additional sensors will make the system more scalable and suitable for large-scale precision agriculture.

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