IOT-Based Smart Plant Monitoring System

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***Abstract*—**Smart agriculture systems enhance crop productivity through automation, real-time monitoring, and intelligent decision-making. This paper presents the design and implementation of an intelligent plant identification and leaf disease detection system integrated with automated irrigation and chemical spraying mechanisms using a Raspberry Pi-based embedded platform.

A lightweight YOLO-based deep learning model (YOLOv8 Nano) is trained offline using a labeled dataset of healthy and diseased plant leaves. The training process is performed on a high-performance computing environment to achieve high detection accuracy. The model is optimized for edge deployment and subsequently deployed on the Raspberry Pi for real-time inference using a camera module. The system detects plant leaves, classifies disease types, and identifies infected regions through bounding box detection. When the detected disease confidence exceeds a predefined threshold, an automated chemical spraying mechanism is activated to prevent further spread.

Environmental parameters such as temperature and humidity are monitored using a DHT22 sensor, while soil moisture levels are measured using a soil moisture sensor. Based on real-time soil moisture readings, irrigation is automatically controlled using a DC pump operated through a relay module to ensure efficient water utilization.

All sensor data, detection results, actuator status, and system parameters are displayed on a web-based dashboard for remote monitoring and control. The proposed system reduces manual intervention, enables early disease diagnosis, optimizes water management, and supports precision agriculture practices. Experimental results demonstrate reliable real-time performance and effective disease detection on a resource-constrained edge device, making the system suitable for smart farming applications.

I. EXISTING SYSTEM

Conventional smart agriculture systems focus mainly on plant identification using traditional image processing and machine learning techniques. Plants are classified based on manually extracted features such as leaf shape, color, texture, and size. Algorithms like Support Vector Machines (SVM), Convolutional Neural Network (CNN), and Naïve Bayes are commonly used for classification.

However, these systems rely on handcrafted features and predefined rules, making them less robust under varying lighting conditions and complex field environments. They typically perform only plant classification without integrating real-time disease detection, automated irrigation, or spraying mechanisms. Additionally, high preprocessing requirements and limited real-time edge processing reduce their effectiveness in precision agriculture applications.

II. DISADVANTAGES OF EXISTING SYSTEM

- Limited Accuracy — Traditional feature-based methods struggle under varying lighting conditions and complex backgrounds.
- Manual Feature Engineering — Requires handcrafted features (shape, color, size), which may not generalize well to different plant varieties.
- No Real-Time Disease Detection — Most systems only identify plant species and do not detect leaf diseases.
- Lack of Automation — No integration with irrigation control or chemical spraying mechanisms.
- Poor Scalability — Difficult to adapt to new plant species or disease types without retraining and redesigning feature extraction models.
- Higher Preprocessing Requirements — Requires background removal, segmentation, and image enhancement steps.
- Limited Edge Deployment Capability — Not optimized for embedded platforms like Raspberry Pi for real-time field applications.

III. PROPOSED SYSTEM

The proposed system is an intelligent smart agriculture solution that integrates plant identification, leaf disease detection, automated irrigation, and chemical spraying using a Raspberry Pi-based embedded platform. A lightweight YOLOv8 Nano deep learning model is trained offline and deployed on the Raspberry Pi for real-time leaf detection and disease classification using a camera module.

When a disease is detected with high confidence, an automatic spraying mechanism is activated to prevent further spread. Soil moisture, temperature, and humidity are continuously monitored, and irrigation is automatically controlled using a relay-operated DC pump. All system data and detection results are displayed on a web dashboard for remote monitoring. The system enables early disease detection, efficient water management, and real-time precision agriculture with minimal human intervention.

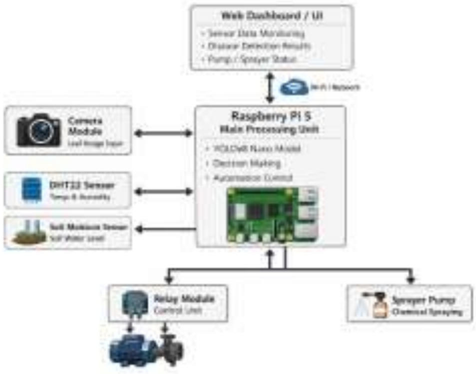

Fig. 1. Architecture Diagram of the Proposed Smart Plant Monitoring System

IV. ADVANTAGES OF PROPOSED SYSTEM

- High Detection Accuracy — Uses a deep learning-based YOLOv8 Nano model for precise plant and disease identification.
- Real-Time Processing — Deployed on a Raspberry Pi for edge-based real-time detection without cloud dependency.
- Early Disease Diagnosis — Detects leaf diseases at an early stage, preventing large-scale crop damage.
- Automated Chemical Spraying — Activates spraying mechanism automatically when disease confidence exceeds a threshold.
- Efficient Water Management — Soil moisture-based automatic irrigation reduces water wastage.
- Reduced Manual Intervention — Fully automated monitoring and control system.
- Remote Monitoring — Web dashboard provides live sensor data, detection results, and actuator status.
- Scalable and Upgradeable — New plant species and diseases can be added by retraining the model.
- Low-Cost and Practical — Suitable for small-scale farms and greenhouse applications.

V. WORKING PRINCIPLE

The proposed smart agriculture system operates by integrating image-based plant disease detection with automated irrigation and spraying control on a Raspberry Pi embedded platform. Initially, the camera module continuously captures real-time images of plant leaves in the field. These images are processed locally using the deployed lightweight **YOLOv8 Nano** deep learning model, which performs object detection and classification to identify plant leaves and determine whether they are healthy or affected by specific diseases. The model generates bounding boxes around infected regions along with confidence scores. If the disease confidence exceeds a predefined threshold value, the Raspberry Pi triggers a relay-controlled chemical spraying mechanism to automatically apply pesticide or treatment to the affected plant area, thereby minimizing disease spread.

Simultaneously, environmental monitoring is performed using sensors connected to the Raspberry Pi. The DHT22 sensor measures ambient temperature and humidity, while the soil moisture sensor continuously checks the water content in the soil. The system compares real-time soil moisture readings with a predefined threshold level. If the soil moisture falls below the required limit, the Raspberry Pi activates a DC water pump through a relay module to initiate irrigation. Once adequate moisture is restored, the pump is automatically turned off to prevent overwatering and conserve water resources.

All collected sensor data, disease detection results, and actuator statuses (pump and sprayer) are transmitted to a web-based dashboard for real-time monitoring and remote supervision. The entire process functions in a continuous loop, ensuring automated plant health monitoring, timely disease control, and optimized irrigation management with minimal human intervention.

VI. BLOCK DIAGRAM

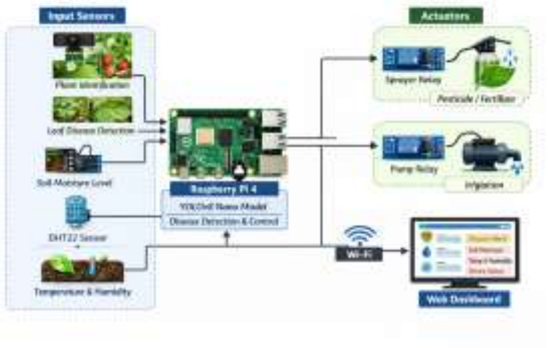

Fig. 1. Block Diagram of the Proposed Smart Plant Monitoring System

VII. HARDWARE COMPONENT LIST

- Raspberry Pi 5
- Camera Module
- DHT22 Temperature and Humidity Sensor
- Relay Module
- DC Water Pump (x2)
- Water Tubing and Spray Nozzle
- MicroSD Card (16GB or higher)

VIII. APPLICATIONS

- Farming Land
- Greenhouse Monitoring
- Smart Agriculture / Precision Farming
- Home Garden / Terrace Garden
- Agricultural Research & Nursery

IX. CONCLUSION

The proposed smart agriculture system integrates real-time plant disease detection, automated irrigation, and chemical spraying using a Raspberry Pi-based platform. By deploying a lightweight YOLOv8 Nano model, the system enables early disease identification and targeted treatment, reducing crop loss and chemical overuse.

The integration of soil moisture and environmental sensors ensures efficient water management through automatic pump control. With remote monitoring via a web dashboard, the system minimizes manual effort and supports precision agriculture. Overall, it provides a cost-effective, reliable, and intelligent solution for modern smart farming applications.

X. LITERATURE SURVEY

Islam et al. [1] proposed a machine learning-enabled IoT system for soil nutrients monitoring and crop recommendation. The system integrates sensor-based data acquisition with ML algorithms to predict nutrient deficiencies and recommend suitable crops, demonstrating improved accuracy in precision farming decision-making.

Alroobaea et al. [2] developed an AI-IoT based smart agriculture pivot for plant disease detection and treatment. The system uses deep learning integrated with IoT sensors to detect plant diseases in real time and apply automated treatment, achieving high detection accuracy in field conditions.

Sharma and Rao [3] presented a smart irrigation system combined with early plant disease detection using IoT and a novel non-linear growing self-organizing map based artificial neural network. The system automates irrigation scheduling while simultaneously identifying early-stage foliar diseases, reducing water wastage and crop loss.

Rana and Vaidya [4] proposed a YOLO-based deep learning framework for real-time multi-class plant health monitoring in precision agriculture. The framework identifies multiple disease classes simultaneously using bounding box detection, enabling rapid and scalable deployment in diverse agricultural environments.

Miao et al. [5] introduced SerpensGate-YOLOv8, an enhanced YOLOv8 model for accurate plant disease detection. By integrating a gated attention mechanism, the model improves detection precision for complex disease patterns on plant leaves with reduced false positives compared to standard YOLOv8.

Chen and Li [6] proposed APD-YOLOv7, which enhances sustainable farming through precise identification of agricultural pests and diseases using a novel Diagonal Difference Ratio IOU loss function. The improved loss metric significantly increases localization accuracy for small-scale pest detection in complex field backgrounds.

The work in [7] described a smart agriculture system for plant disease detection and irrigation management using machine learning and IoT. The combined platform monitors field conditions and triggers irrigation and disease alerts, demonstrating reliable performance across multiple crop types.

Dinesh et al. [8] designed an autonomous IoT-integrated tomato plant disease detection system harnessing the YOLOv8 algorithm and micro-navigation for precision agriculture. The mobile platform navigates crop rows autonomously, capturing and analyzing leaf images in real time to detect tomato-specific diseases with high accuracy.

Kumar et al. [9] examined IoT and IoE transformations in precision farming, covering sensor-based monitoring, automated irrigation, and livestock monitoring. The survey highlights the integration of heterogeneous IoT devices and edge computing to improve resource utilization in modern agricultural systems.

Gorijavolu et al. [10] extended the smart irrigation and disease detection work using IoT and a non-linear growing self-organizing map based ANN, demonstrating that adaptive neural architectures outperform conventional fixed-topology networks for dynamic field condition monitoring.

Khandelwal and Dongre [11] implemented crop disease detection using YOLO V5 on a Raspberry Pi, validating that lightweight YOLO variants can achieve acceptable accuracy on resource-constrained embedded hardware, making on-device inference practical for rural and off-grid farming scenarios.

Kumar G. et al. [12] proposed an automated plant disease detection and prevention system using Raspberry Pi and a CNN algorithm. The embedded CNN model classifies diseased leaves captured by an onboard camera and triggers preventive actions, showing competitive accuracy with low hardware cost.

Wang et al. [13] presented an intelligent identification system for rice leaf disease based on YOLO V5-EFFICIENT. By combining YOLOv5 with an efficient channel attention module, the model improves detection recall for small lesion regions on rice leaves while maintaining real-time inference speed.

Chinnadurai and Selvakumar [14] developed an image-based cotton leaf disease diagnosis system using YOLO and Faster R-CNN techniques. A comparative evaluation revealed that YOLO variants provide faster inference while Faster R-CNN achieves higher localization accuracy, informing model selection for deployment scenarios with different latency constraints.

Lu and Li [15] introduced YOLOWeeds, a novel benchmark of YOLO object detectors for multi-class weed detection in cotton production systems. The benchmark establishes standardized evaluation metrics and datasets, enabling fair comparison of YOLO variants for agricultural weed management applications.

XI. REFERENCES

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