# Smart Irrigation System using Raspberry Pi

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**Abstract**— This project focuses on automated and manual irrigation in addition with plant disease detection and growth monitoring using image processing on a Raspberry Pi 3B+. By leveraging TensorFlow Lite and OpenCV, the system can analyze plant health and trigger appropriate irrigation actions. The aim is to design accurate agriculture system by reducing water wastage and improving crop monitoring.

**Keywords**- Plant Disease Detection, Growth Monitoring, Tensor Flow Lite, Crop Monitoring

## I. INTRODUCTION *(HEADING 1)*

In India, agriculture is the primary source of livelihood for a significant portion of the population. traditionally, groundwater stages were considerably better, resulting in better crop yields. Historically, the identification of diseases has been facilitated by agricultural extension services or similar institutions, like local plant clinics. In recent years, online resources have enhanced these efforts by leveraging the increasing accessibility of the internet. In recent years, these efforts have been enhanced by providing online resources for disease diagnosis, leveraging the growing global access to the internet [1].

Agriculture plays a vital role in sustaining human life by ensuring food production and economic stability. In, traditional farming methods there are significant challenges faced by farmer which includes plant diseases, improper irrigation, and Labor-intensive monitoring. These issues often lead to reduced crop yields, resource wastage, and higher farming costs. Early detection of plant diseases and efficient water management are essential for improving agricultural productivity and sustainability.

This project introduces a Smart Agricultural System that leverages Raspberry Pi [2], AI-based image processing, and IoT automation to enhance farming practices. The system integrates a Raspberry Pi camera for real-time plant disease detection and growth monitoring**,** a YL-69 soil moisture sensor for continuous soil moisture measurement**,** and an automated irrigation system controlled via a relay and water pump**.** To enhance accessibility, the Raspberry Pi transmits real-time sensor data and plant health updates to an HTML-based webpage**,** allowing farmers and researchers to monitor crop conditions remotely through a web interface.

For plant disease detection**,** the system employs a Convolutional Neural Network (CNN)**,** a deep learning technique designed for image classification [3]. The CNN model analyzes images captured by the Raspberry Pi camera, identifying whether a plant is healthy or diseased. Using TensorFlow Lite**,** the model runs efficiently on Raspberry Pi, enabling real-time disease detection with minimal computational resources.

This system integrates machine learning, computer vision, and IoT-driven automation to reduce manual effort, optimize water usage, and facilitate early disease detection. The project focuses on delivering a cost-effective, scalable, and efficient solution for precision agriculture, tackling critical challenges in plant health monitoring and irrigation management. Future enhancements may include cloud-based storage, mobile app integration, and AI model expansion for detecting a broader range of plant diseases, further contributing to sustainable and intelligent farming practices.

## II. RELATED WORK

The current system is a sensor-based setup that utilizes microcontrollers such as Arduino UNO or Node MCU. Various sensors, including the Soil Moisture Sensor, DHT11, Water Level Sensor, and Rain Sensor, are incorporated to monitor different environmental factors. The soil moisture sensor detects the moisture content in the soil and displays the moisture level on an LCD screen [4].

The irrigation motor can be operated in both manners. First one is using a mobile application and another is pressing the

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push button in the field. The soil moisture sensor helps determine the soil's moisture levels, while the DHT11 sensor monitors temperature and humidity conditions in the field. The water level is measured by the water level sensor within the irrigation system and the rainfall is detected by the rain sensor. All sensor data is directly displayed on the LCD, allowing users to easily monitor climatic and soil moisture conditions in the field [4].

## III. Proposed methodology of smart irrigation system

Early disease detection and optimized irrigation management are crucial for improving crop yield, reducing losses, and ensuring sustainable agricultural practices.

This project presents a Smart Agricultural System that integrates AI-based plant disease detection, growth monitoring, and automated irrigation using Raspberry Pi 3B+. The system captures real-time pictures of plant using a Raspberry Pi digicam, then techniques them with OpenCV and TensorFlow Lite to categories plant sicknesses. Soil moisture sensor YL-69 is used for determining the real time reading of moisture present in the soil, and based on the readings, the system automates irrigation using a relay-controlled water pump. This prevents both over-watering and under-watering, ensuring optimal soil conditions for plant growth. Small DC motor which operates on 5v is used for the irrigation purpose. Web-based monitoring is the main feature of the system, it Includes the Raspberry Pi 3B+ model which transmits the live data of plant health and readings of soil moisture sensor to the HTML web page. The users are able to access the data distantly using a web-dashboard which helps in continuous monitoring of plant health, growth, disease type and for controlling irrigation at any location.

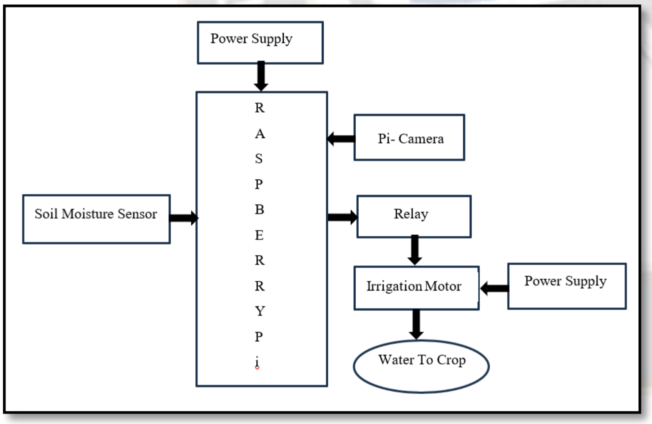


**Fig 1. Block Diagram of Smart Irrigation System Using Raspberry Pi**

By combining the advance technologies like machine learning, image processing, automation in IOT, and real-time web-based monitoring, this system reduces manual labor, optimizes water usage, and ensures early disease detection. The AI model achieves an accuracy of approximately 90% in disease classification, while the automated irrigation system effectively maintains soil moisture at optimal levels. The web interface enhances accessibility, enabling farmers and researchers to monitor plant health remotely and make informed decisions.

This smart agricultural system enhances correctness farming, resource saving, and sustainability. Future enhancements may include cloud-based data storage, mobile app integration, and expanding the AI model to detect a wider range of plant diseases, further advancing the capabilities of automated farming solutions.

## IV. Design Methodology

### *A. Data Acquisition*

Data acquisition refers to the process of collecting real-time data from various sensors and devices for analysis [5]. In this data acquisition process the collection of statistical data is very crucial role because it helps in monitoring plant health, identification of diseases and the management of efficient irrigation. The Raspberry Pi 3B+ model is the part of the overall system which is used as s controller and which also utilizes as a data acquisition element. The input collection from different sources, including:

- Raspberry Pi Camera for capturing images of plant leaves to assess growth and detect diseases [6].
- The soil moisture sensor YL-69 used to mapped the moisture level in the soil which helps in irrigation purpose.
- Water pump based on soil moisture sensor controlled by relay module.

### *B. Data Preprocessing and Transmission*

Data preprocessing is essential to ensure accuracy and consistency in the collected sensor data [3]. The plant images data and the raw data from soil moisture sensor preprocessed using various techniques.

- Image Preprocessing: OpenCV is used for resizing, filtering, and feature extraction before sending the image to the CNN version for type.
- Threshold Calibration: The system applies predefined moisture level thresholds to determine when irrigation is required.

After preprocessing, the data is then transmitted to the remote monitoring system from the controller Raspberry Pi 3B+.The Flask framework is used to enable a local web server where users can access real-time plant health and soil moisture data via an HTML-based webpage.

### *C. Web-based Communication (Flask and TCP/IP Communication*

The real-time monitoring for the system uses TCP/IP communication and a Flask web server to send and receive data between the Raspberry Pi and the user interface. The Raspberry Pi collects and processes data, then transmits it to a web-based dashboard, where users can monitor plant conditions remotely.

- Raspberry Pi serves as the web server**,** hosting an HTML-based monitoring page.

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- Sensor data is continuously updated on the web page to provide real-time insights into soil moisture and irrigation status.
- The user can remotely access the system from a laptop or smartphone to check plant health, view irrigation logs, and adjust parameters.

### D. *Data Analysis*

Once the data is transmitted, it undergoes real-time analysis to generate meaningful insights**.** The analysis includes:

- CNN-Based Disease Detection: The captured plant images are processed using a Convolutional Neural Network (CNN) to classify leaves as healthy or diseased. The model recognizes patterns such as leaf discoloration, spots, or fungal infections [7].
- Growth Monitoring: Images are compared over time to detect growth trends, using image processing techniques to measure plant height and leaf expansion.
- Soil Moisture Evaluation [8]: The YL-69 soil moisture sensor analyses the real time data and then evaluate this data against the predefined threshold values to determination of irrigation
- Decision Making: when soil moisture tiers drop beneath the predefined threshold, the system routinely activates irrigation by way of switching at the water pump through the relay module.

### E. *Result Transmission*

After complete analysis of the collected data and the necessary information, the Raspberry Pi updates the web-based dashboard with real-time results. The system displays show the below parameters:

- Plant disease detection: Identification of whether a plant is healthy, infected, or affected by a specific disease type is shown on the dashboard.
- Growth Monitoring showing plant development over time.
- Soil Moisture Levels with irrigation recommendations.
- Pump Status (ON/OFF) based on moisture readings.

### F. *Display and User Interaction*

The Raspberry Pi includes a user-friendly web interface for the monitoring of real-time status of plant health and automated irrigation control. The interface is built using HTML, CSS, and JavaScript**,** with Flask handling the backend communication.

- The web page updates live sensor data and CNN results in a structured format.
- We can distantly monitor all the conditions like soil condition, result of disease detection with giving solution for the particular disease and tracking the plant growth.
- The system ensures automated irrigation without manual intervention**,** while still allowing users to override the automation when needed.

## V. ALGORITHMS

1. Start
2. Initialize the Raspberry Pi GPIO pins for sensor and relay control
3. Read the YL-69 soil moisture sensor value (analog or digital output)
4. Examine the moisture degree with the predefined threshold
5. If the moisture degree is under the threshold (soil is dry):
   - Turn on the relay to turn on the water pump.
   - constantly reveal the moisture level.
6. Else, if the moisture stage is at or above the threshold (soil is adequately wet):
   - Turn OFF the relay to stop the water pump
7. Send real-time soil moisture data to the web-based monitoring system
8. Repeat the process in a loop to ensure continuous monitoring
9. End

## VI. WORKING

### A. *Image Processing for Disease Detection*

The Plant images which are captured using Pi camera are then pre-processed with help of OpenCV. The characteristics of plant leaves and real time analysis of plant leaves using Pi camera transmits to the trained tensor flow lite model for detection of plant diseases. The results are displayed on web dashboard with the parameter like disease type and disease solution [7].

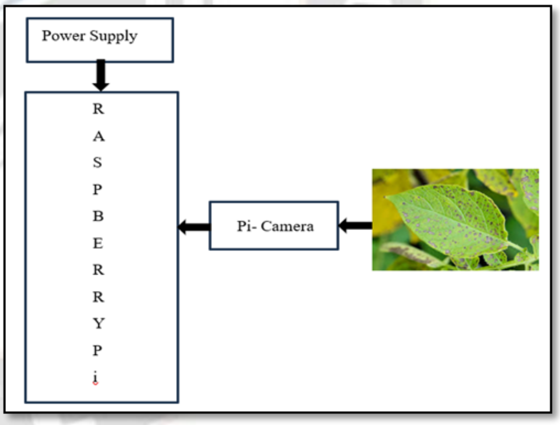


**Fig 2. Block Diagram for disease detection**

### B. *Plant Growth Monitoring*

Camera module captures the real time pictures of plant and transmits the data to the Raspberry Pi 3B+ model for performing the analysis using image processing technique so, in accordance with the leaf color and leaf size the growth percentage of plant display on web-based dashboard. Image processing techniques measure plant height and detect growth anomalies.

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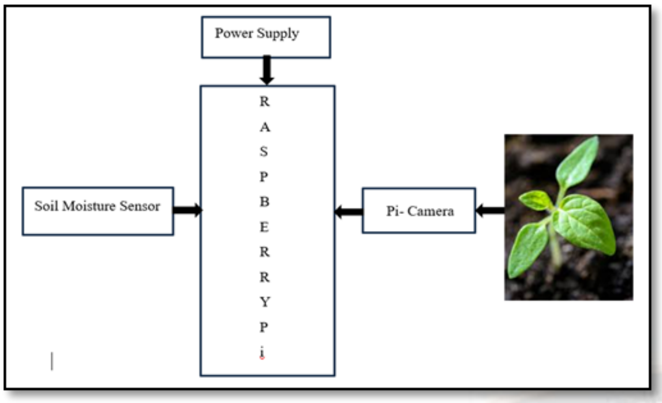


**Fig 3. Block Diagram for plant growth monitoring**

*C. Soil Moisture Detection and Automated Irrigation*

The irrigation based on the soil moisture sensor YL-69 is done in both ways Automated and manual. The soil sensor which detects the moisture level in the soil. When the moisture level falls below the threshold level the relay module turn on the water pump. Likewise, when the moisture level in the soil is above the threshold water pump gets turn off [9]. The motor used for irrigation purpose is small DC water pump which operates on 5v DC and controlled by relay module.

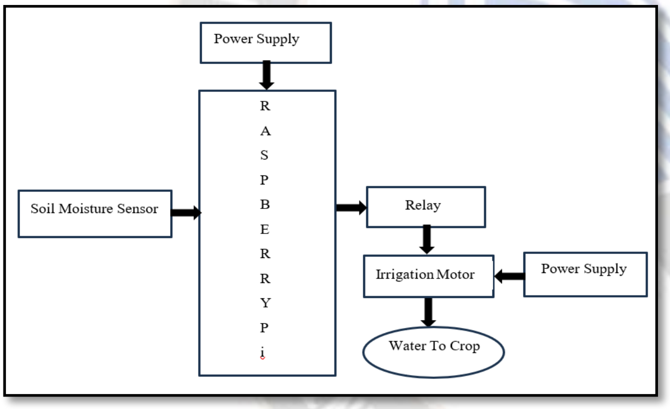


**Fig 4. Block diagram of Automation irrigation**

VII. RESULTS

*A. Overall System*

In this study, we conducted a comprehensive analysis of the collected data to evaluate the performance of our proposed methodology. The real time images are captured using Pi camera, then this collected data transferred to the raspberry Pi 3B + model. After doing processing on captured data using convolutional neural network (CNN) and deep learning algorithms, the result is seen on the web-based dashboard. On the web-based dashboard gives the results of Plant growth monitoring, measurement of soil moisture level to perform automated irrigation and the disease detection and the solution for particular disease using image processing technique.

This overall system is beneficial to decrease manual labor, Image processing-based detection of disease increase the crop health. Also, we can access the system remotely it becomes easy to control the water management from any location. So, it leads to save water. This project currently in its prima phase. The disease detection technique is specifically designed for potato crops. With further development and testing, this image processing technique can be expanded for broader application across various crops.

There are various challenges like accuracy of sensors, variation of light while capturing of image and any other environmental conditions affect the sensor reading. Potential solutions include calibrating sensors, improving image preprocessing techniques, and integrating additional environmental sensors for more precise monitoring.

**Fig 5. Overall Setup**

*B. Plant Growth Monitoring*

This project presents an advanced Smart Agricultural System that utilizes Raspberry Pi, AI-powered image processing, and IoT-based automation to optimize farming operations. The system incorporates a Raspberry Pi camera to monitor plant growth in real time, along with a YL-69 soil moisture sensor for continuous tracking of soil moisture levels. To improve accessibility, real-time sensor data and plant health insights are transmitted to an HTML-based webpage, enabling farmers and researchers to remotely monitor crop conditions via a web interface.


**Fig 6. Plant Growth Monitoring**

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## *C. Image Processing for Disease Detection*

The deep learning analysis was conducted using a Convolutional Neural Network (CNN) model for plant disease detection, which yielded promising results in terms of accuracy, precision, and recall**.** The model successfully classified healthy and diseased plants based on visual features such as color variations, texture, and leaf damage**.** The captured image of leaf of plant is compared with the standard dataset using Convolutional Neural Network (CNN) gives the accurate prediction about disease detection and the disease solution [10]**.** Currently this project is Prima phasing is applicable for only Potato crop with additional work and test this image processing technique can be deployed horizontally across most of the cost.

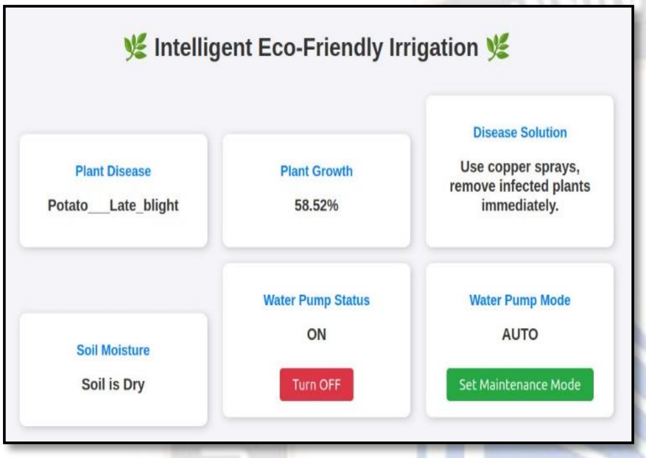


**Fig 7. Disease Detection Output**

## *D. Soil Moisture Detection and Automated Irrigation*

The system effectively monitored soil moisture levels in real time and controlled the water pump accordingly. The relay module was triggered whenever the soil moisture dropped below the predefined threshold**,** ensuring optimal irrigation while preventing water wastage. The comparison between manual and automated irrigation showed a significant reduction in water consumption and improved plant health.


**Fig 8. Auto Irrigation for Dry Soil**

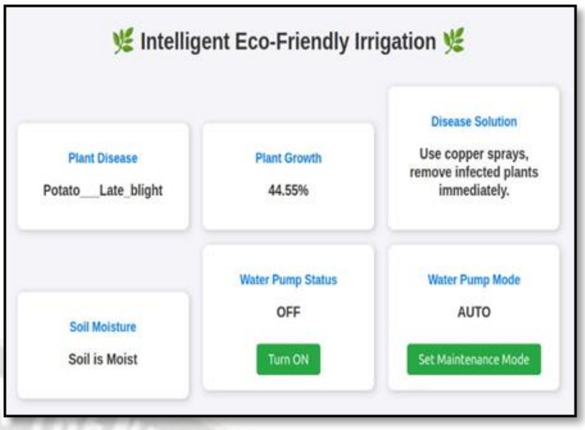


**Fig 9. Auto Irrigation for Moist Soil**

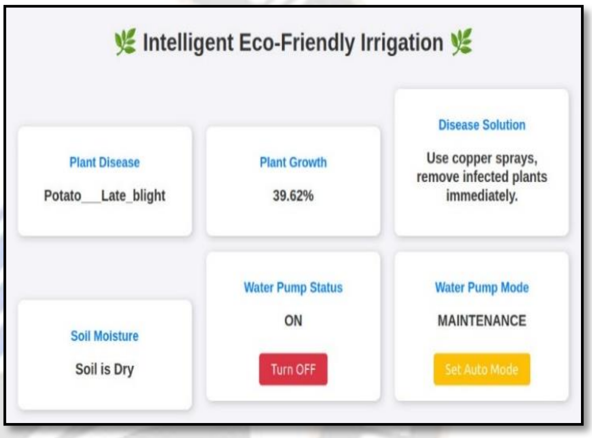


**FIG. 10 MANUAL MODE OF IRRIGATION**

# VIII. CONCLUSION

This project successfully designed a smart and automated agricultural system with control unit Raspberry Pi 3B+ model for plant disease detection, growth monitoring, and soil moisture-based irrigation control using IoT, sensors, and deep learning techniques**.** By integrating Raspberry Pi, a camera module, a YL-69 soil moisture sensor, and a relay-controlled water pump, we developed a real-time system for monitoring and automated irrigation.

The application of Convolutional Neural Networks (CNNs) enabled accurate classification of plant diseases**,** while the soil moisture sensor and relay module automated the irrigation process**,** ensuring optimal water usage**.** Although challenges such as sensor calibration and environmental fluctuations were encountered, the system demonstrated high accuracy and reliability in disease detection and water management. Additionally, the web-based dashboard improved accessibility, allowing farmers to remotely track plant health and soil conditions. Data analysis reinforced the potential of AI and IoT in precision agriculture, showcasing their ability to minimize manual labours, prevent water wastage, and enhance crop health. Future improvements could focus on enhancing model

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accuracy, integrating additional environmental sensors, and expanding the system to cover large-scale agricultural fields**.** Overall, this project contributes to the advancement of smart farming and precision agriculture**,** laying a strong foundation for future research and real-world applications in AI-driven plant health monitoring and automated irrigation systems**.**

## Acknowledgment

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