

Smart Irrigation System with Remote Plant Health Analysis

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Abstract

We focus on developing an Automatic Plant Watering System using Arduino and ESP32 to enhance plant care through automated irrigation and predictive health analysis. The system integrates a soil moisture sensor to monitor moisture levels continuously and activate a water pump when the soil moisture drops below a specified threshold, ensuring optimal watering. In addition to automated irrigation, the system assesses plant health by analyzing environmental parameters such as temperature, humidity, and soil moisture levels. These data are collected in real-time, stored in the cloud, and processed to predict the plant's health status. The real-time data and health predictions are displayed on the Blynk app or website, providing users with a convenient way to monitor their plants remotely. By leveraging IoT technologies, cloud storage, and predictive analytics, this system aims to minimize human intervention, improve plant health management, and offer a sustainable solution for plant care.

Keywords: *Arduino controller, Monitoring plants, Health Prediction, Automatic Watering, Plant care practices*

I INTRODUCTION

The demand for efficient and sustainable plant care solutions has grown significantly in recent years, driven by the need to optimize water usage and improve plant health. Traditional watering methods often result in overwatering or under watering, negatively impacting plant growth. To address these challenges, this project proposes the development of an Automatic Plant Watering System using Arduino and ESP32, designed to automate irrigation and provide predictive health assessments for plants. The system uses a soil moisture sensor connected to an Arduino to continuously monitor the moisture content of the soil. When the moisture level falls below a predefined threshold, the Arduino triggers a water pump to irrigate the plants, ensuring they receive the right amount of water at the right time. In addition to automated watering, the system incorporates a predictive health assessment feature that evaluates plant health by considering environmental factors such as temperature, humidity, and soil moisture. These data are processed and analyzed in real-time, and the results are displayed on the Blynk app or website, allowing users to monitor their plants remotely and make informed decisions. By integrating IoT technologies, cloud storage, and data analytics, this system not only simplifies plant care but also promotes sustainable practices. The solution is ideal for both amateur and professional gardeners, aiming to reduce manual intervention, conserve water, and enhance overall plant health.

A. Objective and Contributions

In this work, we have the aim of developing an Automatic Plant Watering System using Arduino and ESP32. The system integrates a soil moisture sensor for continuous monitoring and activates a water pump when moisture levels fall below a set threshold.

- **Manual Watering:** Requires constant attention and regular scheduling. Labor-intensive and prone to human error, leading to excess watering or less watering.
- **Lack of Remote Monitoring:** Typically do not offer remote monitoring or control, limiting their effectiveness and convenience for users.
- **Inadequate Plant Health Monitoring:** Do not provide real-time data or predictive analytics on plant health [6], making it challenging to maintain optimal growing conditions.
- **Timer Based Automated System:** Use simple timers to schedule watering at fixed intervals. Lack adaptability to threshold. Additionally, it assesses plant health by analyzing environmental parameters like temperature, humidity, and soil moisture. Data is collected in real-time, stored in the cloud, and processed to predict plant health. The system minimizes human intervention, improves plant care through predictive analysis, and allows remote monitoring [7] via the Blynk app or website.

Below is a summary of the research's contribution.

- An Automatic Plant Watering System using Arduino and ESP32, integrating a soil moisture sensor to automate irrigation when moisture drops below a threshold. It monitors environmental factors like temperature, humidity, and soil moisture to predict plant health, storing real-time data in the cloud.
- Users can remotely monitor plants through the Blynk app or website, utilizing IoT and predictive analytics to enhance plant care and sustainability. The system minimizes human intervention and optimizes plant health management.

B. Structure of the Paper

Section II of the paper studies numerous similar works. Section III demonstrates the methodology utilized as Proposed Methods, in Section IV for results analysis and Discussion, and Section V summarizes the current research and Section VI specifies the future scope.

II RELATED WORK

Several studies have explored the development of smart irrigation systems leveraging IoT and cloud-based technologies. A smart irrigation system [1] that utilizes cloud integration to manage water usage in agriculture efficiently, demonstrating significant improvements in water conservation and plant health management. A cloud-based monitoring system for real-time plant health assessment [2], using environmental sensors to predict plant health and optimize water usage. An predictive analytics in plant care systems [3], where data from soil moisture and environmental sensors were processed to predict irrigation needs. An automated health assessment system [4] using sensors to monitor soil moisture, temperature, and humidity, providing remote monitoring and predictive health analysis for plant care. An IoT-based system using ESP32 for automated irrigation [5], integrated with cloud storage and health prediction algorithms for optimizing plant watering schedules.

EXISTING METHOD

- **Inefficiency:** Do not adjust for weather changes, resulting in water wastage during rainy periods or inadequate watering during dry spells.
- **Manual Watering:** Requires constant attention and regular scheduling. Labor-intensive and prone to human error, leading to excess watering or less watering.
- **Lack of Remote Monitoring:** Typically do not offer remote monitoring or control, limiting their effectiveness and convenience for users.
- **Inadequate Plant Health Monitoring:** Do not provide real-time data or predictive analytics on plant health [6], making it challenging to maintain optimal growing conditions.
- **Timer Based Automated System:** Use simple timers to schedule watering at fixed intervals. Lack adaptability to real-time soil moisture levels and environmental conditions.

III. PROPOSED METHOD

System Design

- **Arduino and ESP32 Integration:** Connect an Arduino Uno to an ESP32 to manage sensor data collection and communication to the cloud.
- **Real-Time Monitoring**
Continuously monitors soil moisture [9] levels to ensure optimal watering. Prevents excess watering and less watering by responding to real-time data.
- **Water Pump Control:** Interface a relay module with Arduino to control the water pump based on moisture readings.
- **Predictive Health Assessment:** Measure environmental parameters like temperature and humidity using a DHT11 sensor. Uses predictive analytics to assess whether the plant's environmental conditions are within sustainable limits.
- **Water Pump Control:** Interface a relay module with Arduino to control the water pump based on moisture readings

Data Acquisition

- **Soil Moisture Sensor:** Continuously monitor soil moisture levels and send analog readings to the Arduino.
- **Temperature and Humidity Monitoring:** Use a DHT11 sensor connected to the Arduino to measure temperature and humidity.
- **Data Transmission to ESP32:** Send processed data from the Arduino to ESP32 via serial communication

Cloud Storage And Analysis

- Data Storage on Blynk: ESP32 transmits data to the Blynk cloud, where real-time data is displayed and stored.
- Health Prediction Algorithm[10]: The Arduino processes sensor data [8] to assess plant health using an algorithm based on predefined environmental thresholds.

Watering Control Algorithm

1. Check soil moisture level.
2. If below the threshold, calculate watering duration based on soil moisture deficit, temperature, and humidity.
3. Activate the water pump for the calculated duration.
4. Re-evaluate soil moisture and repeat the process

Objective: Calculate the watering duration based on soil moisture level, temperature, and humidity.

1. Input:

- soilMoistureValue: Current soil moisture level (analog reading)
- temperature: Current temperature (float)
- humidity: Current humidity (float)

2. Initialize Variables:

- MAX_SOIL_MOISTURE = 600
- MIN_WATERING_DURATION = 1000 (1 second)
- MAX_WATERING_DURATION = 10000 (10 seconds)

3. Calculate Moisture Deficit:

- If soilMoistureValue > MAX_SOIL_MOISTURE:
Moisture Deficit = soil Moisture Value - MAX_SOIL_MOISTURE
moisture Range = 1023 - MAX_SOIL_MOISTURE
Duration = map(moisture Deficit, 0, moisture Range, MIN_WATERING_DURATION, MAX_WATERING_DURATION)

4. Adjust Duration Based on Temperature and Humidity:

- If temperature > 30:
duration += 2000 (Increase duration by 2 seconds)
- If humidity > 70:
duration -= 2000 (Decrease duration by 2 seconds)

5. Constrain Duration:

- duration = constrain(duration, MIN_WATERING_DURATION, MAX_WATERING_DURATION)

6. Output:

- Duration: Calculated watering duration in milliseconds.
- humidity: Current humidity (float)
- soil Moisture Value: Current soil moisture level (analog)

Plant Health Assessment Algorithm

1. Measure temperature, humidity, and soil moisture
2. Assign scores based on ranges for each parameter.
3. Calculate the total health score and determine health status:
4. Good: Score ≥ 7
5. Moderate: Score between 3 and 6
6. Poor: Score < 3

Objective: Determine the health status of the plant based on temperature, humidity, and soil moisture.

1. Input:

- temperature: Current temperature (float)

2. Initialize Variables:- health Score = 0

3. Assess Temperature:

- If temperature ≥ 20 and temperature ≤ 30 :
Health Score += 3 (Optimal)

- Else if temperature ≥ 15 and temperature ≤ 35 : health Score += 1 (Tolerable)
- Else: Health Score -= 2 (Critical)

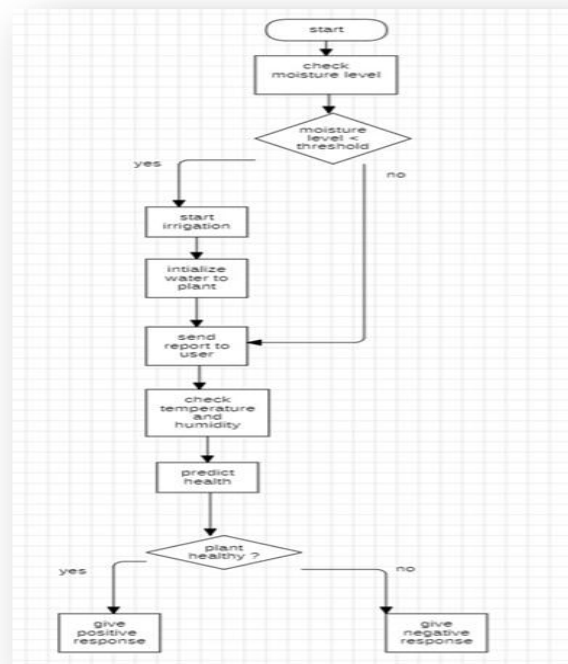


Fig 1 Process Flow Diagram

4. Assess Humidity:

- If humidity ≥ 40 and humidity ≤ 70 :
Health Score += 3 (Optimal)
- Else if humidity ≥ 30 and humidity ≤ 80 :
Health Score += 1 (Tolerable)
- Else:
Health Score -= 2 (Critical)

5. Assess Soil Moisture:

- If soilMoistureValue ≥ 400 and soilMoistureValue ≤ 600 :
Health Score += 3 (Optimal)
- Else if soilMoistureValue ≥ 300 and soilMoistureValue ≤ 700 :
Health Score += 1 (Tolerable)
- Else:
Health Score -= 2 (Critical)

6. Determine Health Status:

- If health Score ≥ 7 :
Health status is "Good"
- Else if health Score ≥ 3 :
Health status is "Moderate"
- Else:
Health status is "Poor"

7. Output:

- Health Status: String indicating plant health status ("Good", "Moderate", "Poor").

IV. RESULT AND DISCUSSION

The system must use a soil moisture sensor to continuously monitor the moisture levels of the soil. The Arduino controller must activate a water pump to irrigate the plant when the soil moisture level drops below a predefined threshold. Collect real-time data on temperature and humidity using appropriate sensors. Analyze collected data (soil

moisture, temperature, humidity) to make predictions about the plant's health. The health prediction algorithm must consider the specific environmental conditions that the plant can sustain. Real-time sensor readings and health predictions to the Blynk app or website. The Blynk interface must display current soil moisture levels, temperature, humidity, and health predictions. Users must be able to remotely monitor plant conditions via the Blynk app on their smartphones or web interface. Generate alerts and notifications on the Blynk app when critical conditions are detected, such as extremely low soil moisture or unhealthy predicted status. [14], [15]. The discussion can be made in several sub-sections.

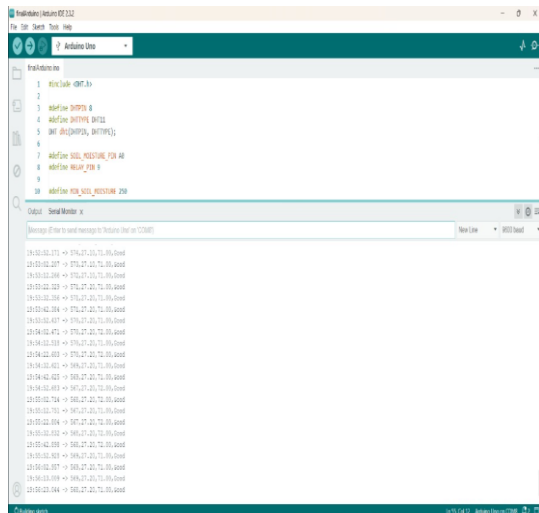


Fig 2: Result Shows

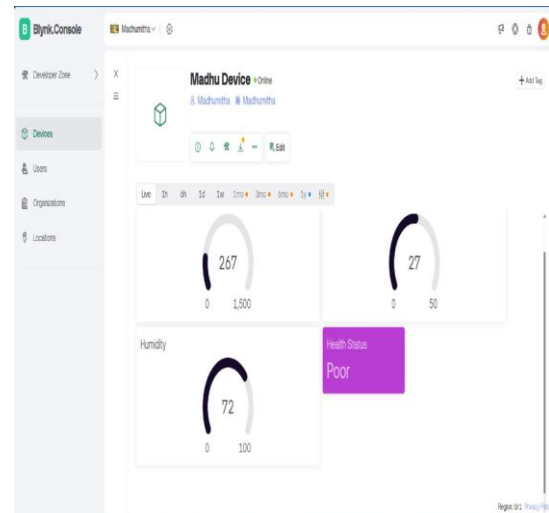


Fig 3: Health status 'Humidity'

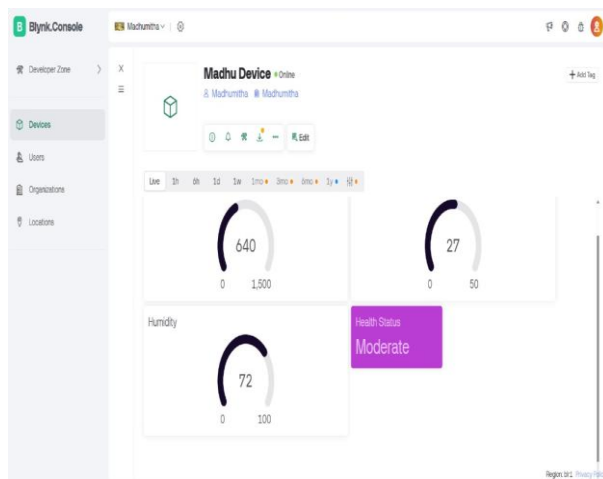


Fig 4: Health status 'Moderate'

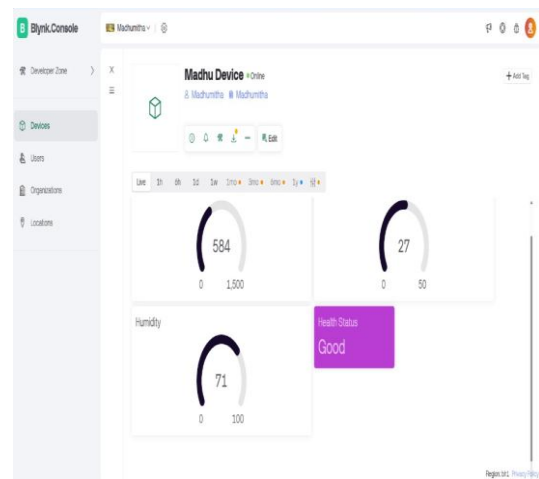


Fig 5: Health status 'Good'

The system effectively automated the watering of plants based on soil moisture levels [10], preventing both excess watering and less watering. Predictive health analysis provided accurate assessments of plant health, allowing timely interventions [11]. Real-time data on soil moisture, temperature, humidity, and health status were successfully transmitted to the Blynk app, enabling remote monitoring and management.

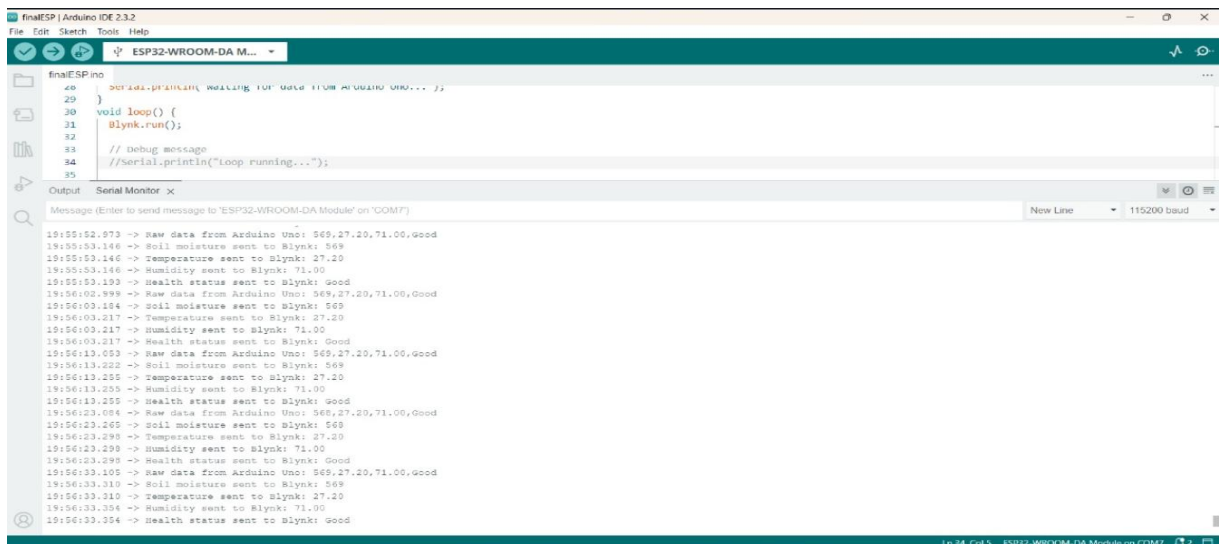


Fig 6: Result shows in Arduino IDE 2.3.2

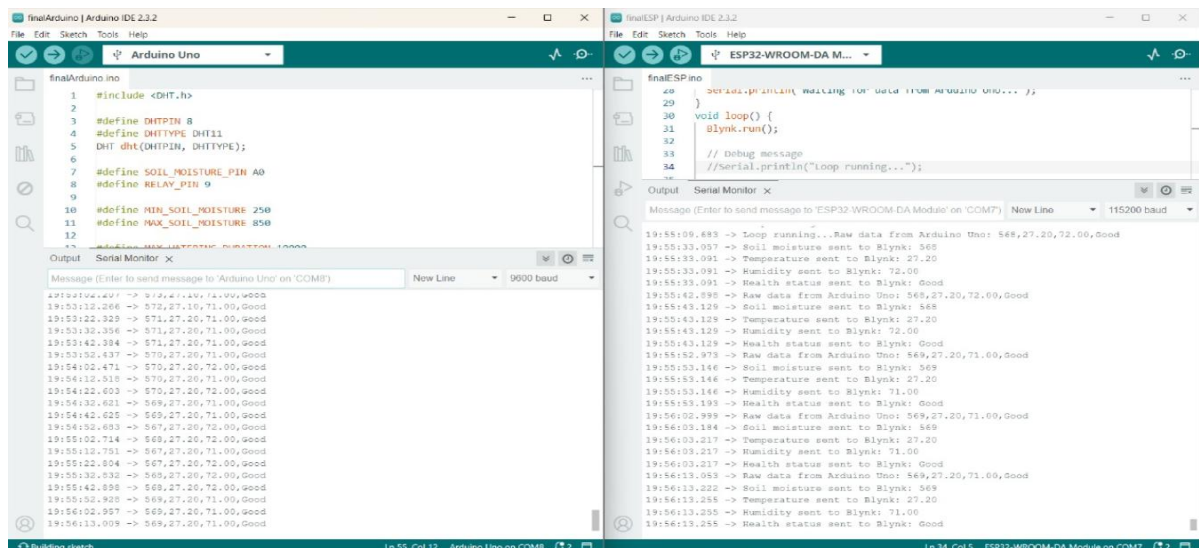


Fig 7: Send message to 'Arduino Uno' on COMB

The system demonstrated improved plant care management reducing manual intervention and ensuring optimal environmental conditions for plant growth.

V. CONCLUSION

The Automatic Plant Watering System using Arduino and ESP32 effectively integrates automated irrigation with predictive health analysis to optimize plant care. The system's ability to automatically water plants based on real-time data [17] and provide health insights enhances both the efficiency and sustainability of plant care practices. With cloud integration and remote monitoring capabilities through the Blynk app, this solution offers a reliable tool for amateur and professional gardeners alike, minimizing human intervention and promoting sustainable water usage. The implementation of IoT technologies and predictive analytics [16] in this system sets a foundation for future advancements in smart gardening and agricultural automation.

VI. FUTURE SCOPE

The Smart Plant Watering System with Cloud Analysis and Health Prediction can be further enhanced by incorporating advanced machine learning algorithms for more accurate plant health predictions. Future research could explore the integration of additional environmental sensors, such as light intensity and CO₂ levels, for a more comprehensive understanding of plant growth factors. Expanding the use of cloud-based irrigation systems is a key direction for advancing precision farming techniques. Expanding the system's scalability to larger agricultural fields and improving its energy efficiency through solar-powered IoT devices will contribute to sustainable farming. Additionally, using predictive analytics for early detection of plant diseases and automated fertilization systems could enhance the system's effectiveness.

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