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A Smart Plant Monitoring System Using Arduino

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***Abstract:** In recent years, the integration of automation and IoT technologies in agriculture has gained significant attention for improving resource efficiency, sustainability, and productivity. This paper presents a Smart Plant Monitoring System using Arduino, designed to automate irrigation and enhance plant care by continuously monitoring soil moisture, temperature, and humidity levels. The system employs an Arduino Uno microcontroller, soil moisture sensor, DHT11 temperature & humidity sensor, relay module, LCD display, and water pump to develop an intelligent irrigation system. Experimental results demonstrate a 30-40% reduction in water consumption and improved irrigation efficiency. The study highlights future improvements, including AI-based predictive analytics, IoT-enabled remote monitoring, and solar power integration. The proposed system is aimed at both small-scale urban gardening and large-scale agricultural applications, offering a cost-effective and scalable solution..*

***Index Terms:** Smart Agriculture, Arduino, Precision Farming, Automated Irrigation, AI-based Irrigation, Cloud Computing, Sustainable Farming.*

I. INTRODUCTION

With increasing global water scarcity and the need for sustainable agricultural practices, automated irrigation systems have become a necessity. Traditional irrigation methods often lead to inefficient water use, increased manual labor, and unpredictable plant growth conditions. Smart farming technologies, particularly IoT-driven solutions, offer innovative ways to optimize agricultural processes. The proposed Smart Plant Monitoring System integrates IoT technology with automation to optimize water usage and enhance plant health. By leveraging sensors and microcontrollers, this system provides an efficient and cost-effective solution for small-scale farming, home gardening, and greenhouse monitoring.

II. LITERATURE SURVEY

Several research efforts have explored Arduino-based Plant Monitoring systems for various applications, highlighting the potential and versatility of this platform.

Anuj Nayak et al., 2014 describe that sensor nodes batteries are charged by using harnessing wind energy. A routing algorithm named DEHAR is proposed to extend overall batteries power. The proposed method is efficient where the amount of sensor nodes very low because of latency experienced due to synchronous sleep scheduling. A small band belt used to harness wind energy to sensor nodes. Wind belt is aero elastic flutter, which is capable for harnessing wind energy. Harnessing wind energy is a renewable energy source. However, the main problem using harnessing wind energy is the unreliability as the power of the wind is not permanent.

Sherine M. Abd El -ka der et al., 2013 proposed APTEEN (Periodic Threshold old sensitive Energy Efficient sensor network protocol. APTEEN is a Hierarchical based routing protocol in which nodes have grouped into clusters. Each cluster has a head node and head node is responsible for broadcast data to the base station. APTEEN broadcast parameters attribute, which is a set of physical parameters, in which the user is interested to obtain info, Thresholds value as Hard Threshold and Soft Threshold, Schedule as TDMA schedule uses to assign slots to save energy, which provide collision free transmission. It controls the energy consumption by changing threshold values and count time. The performance of proposed protocol is better than LEACH on average 79% and by LEACH-C on average 112%.

SbrineKhriji et al., 2014 describe different type of sensor nodes for real monitoring and control of irrigation system. Each node consists of B mote and actuator. TelosB mote is an ultralow power wireless module for monitoring applications. Soil nodes used to measure the soil moisture weather nodes used to measure environmental parameter and actuator used for controlling the opening of valves for irrigation. The system has cost efficient and reduce the power consumption The experimental result shows that the plants are well irrigate and if there is any change in threshold value the system alert to farmer about the problem to take the appropriate decision..

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Yunseop Kim et al., 2008 represents real time monitoring and control of variable rate irrigation controller. The sensor nodes measure environmental parameter and transmit data to base station where base station process data through a user-friendly decision making program and all data commands send to irrigation control station. The Irrigation control station sends machine location using GPS to the base station, send control signal back to irrigation control

III. SYSTEM OVERVIEW

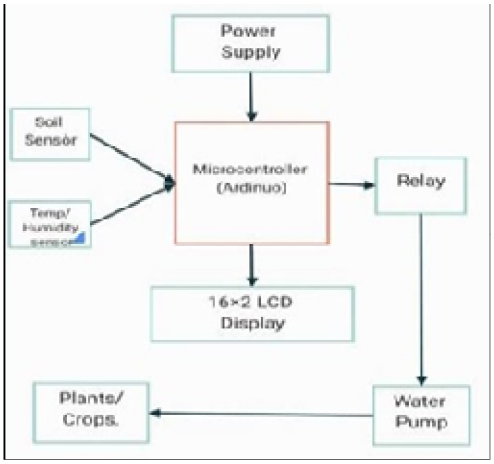

Fig.1.BlockDiagram

1) *Arduino Uno R3 (Microcontroller):* Acts as the central controller of the system, processing sensor inputs and controlling actuatorslike the water pump. Arduino Uno is cost-effective, widely used, and offers sufficient I/O pins toconnect the required components.
2) *Soil Moisture Sensor:* Measures the moisture level in the soil to determine when theplant needs watering.Moisturesensors are crucial for detecting soil hydration and ensuring plants are watered only whennecessary, avoiding over-watering.
3) *DHT11 Temperature and Humidity Sensor:* Measures the ambient temperature and humidity around the plant Temperature and humidity play signicant roles in plant growth, so monitoring these factors ensures optimal conditions for plant health
4) *Water Pump (5V):* Activates to water the plant when the moisture sensor detects dry soil.A 5V pump is efficient for small-scale gardening applications, ensuring proper irrigation basedon soil moisture levels.
5) *Relay Module (5V):* Serves as an interface to control high-power devices, like the water pump, through the Arduino. Relays are essential for safely controlling power-hungrycomponents with the low-powerArduino board
6) *LCD Display (16x2):* Displays real-time data such as soil moisture and temperature, providing feedback to the user.An LCD is simple to interface with Arduino and provides easy access to system data, allowingusers to monitor plant conditions without a computer or mobile app
7) *Power Source (9V Battery):* Powers the entire system, including the Arduino, sensors, and water pump.A 9V battery or similar power supply is adequate to run the Arduino and connected componentswithout frequent recharging or changes
8) *Jumper Wires:* Used to connect various components, such as sensors, relays, and the Arduino. Essential for making all the necessary connections between sensors, actuators, and the microcontroller.

IV. PARTS EXPLANATION

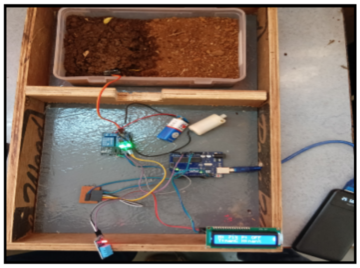
Fig.2.KITPHOTO

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A. Software Components

1) Arduino IDE: Programming platform used for system implementation.
2) Embedded C: Language used for sensor interfacing and decision-making logic.
3) IoT Integration (Future Work): The system can be connected to cloud platforms such as ThingSpeak or Firebase for remote monitoring and data analytics.
4) Machine Learning Integration (Future Scope): AI models can be trained to optimize irrigation schedules based on weather predictions and soil data.

B. Working Mechanism:

The soil sensor and temperature/humidity sensor send data to the Arduino. The Arduino processes this data and decides whether the soil needs water. If moisture is low, the Arduino triggers the relay, turning on the water pump. Once the soil moisture reaches the required level, the Arduino stops the pump. The LCD display provides real-time data about the system's status. This setup ensures efficient water management by automating irrigation, reducing manual effort, and optimizing water use.
KeypadPins: Rowsandcolumnsareconnectedtopins6- 9 and 2-5, respectively.

C. Data flow Between Components

1) Sensors collect real-time environmental data.
2) Data is sent to the Arduino Uno microcontroller.
3) Arduino processes data based on predefinedthesholds.
4) If soil moisture is below the set level, Arduino triggers the relay module to turn ON the water pump.
5) Sensor data and system status are displayed on the LCD screen.

D. Working Principle

1) Sensor Data Collection: Soil Moisture Sensor measures soil dryness. DHT11 Sensor measures temperature and humidity. Data is sent to Arduino.
2) Processing by Arduino: Arduino analyzes the data and compares it with predefined thresholds. If soil moisture is below 30%, it activates the relay module. If soil moisture is sufficient (>50%), it deactivates the relay.
3) Water Pump Control: If relay is ON, the pump starts watering. If relay is OFF, the pump stays OFF.
4) LCD Display Update: Displays real-time sensor values:
   Temp: 30°C   Moisture: 40%
   Humidity: 45%   Pump: ON
5) Pump Status (ON/OFF) is displayed based on moisture conditions.

Thus, an automated plant monitoring and irrigation system using Arduino Uno uses real-time sensor data collection (Soil Moisture + Temperature + Humidity) with relay-controlled water pump based on soil conditions and user feedback through LCD display. Efficient power management using external battery and regulated voltage levels. This system helps reduce manual effort, optimize water usage, and ensure healthy plant growth through smart automation.
Setup(setup()function):

a) *Circuit Connections:*

- Arduino UNO/Nano: Acts as the brain of the system, controlling sensor inputs and pump output.
- Soil Moisture Sensor:
  - VCC → 5V on Arduino
  - GND → GND on Arduino
  - A0 (Analog Output) → A0 on Arduino
- *DHT11/DHT22 (Temperature and Humidity Sensor):*
  - VCC → 5V on Arduino
  - GND → GND on Arduino
- *Relay Module:*
  - VCC → 5V on Arduino
  - GND → GND on Arduino

- IN → Digital Pin (e.g., D8)
- Relay Output → Connected to pump circuit (be cautious with AC connections or use a 12V DC pump for safety)
- *Water Pump:*
- Powered through relay and external 12V DC power supply

b) Power Supply:
- Arduino powered via USB or 9V adapter
- Pump powered via 12V power supply, isolated from Arduino (relay in between

c) Mounting:
- Secure sensors in soil near the plant
- Place DHT sensor in open air for accurate environmental readings
- Keep pump inlet in a water reservoir and outlet aimed at the plant's root zone

6) KeyFunctionalFlow:
- Arduino powers on and initializes all sensors.
- Soil moisture sensor reads the current soil moisture level.
- DHT11/DHT22 sensor reads the ambient temperature and humidity.
- Arduino compares soil moisture value with a predefined threshold.
- If moisture level is low:

Arduino sends signal to relay module.
Relay activates the water pump.
Pump waters the plant for a fixed time
- If moisture level is sufficient:

Pump remains OFF, no irrigation needed.
- System loops the process at regular intervals

ErrorHandling:
- The soil moisture sensor readings varied with different soil types, requiring manual calibration.
- DHT11 temperature and humidity readings sometimes lagged, affecting response time.

V. RESULTS AND DISCUSSION

The experimental results demonstrated that the smart irrigation system successfully monitors soil moisture, temperature, and humidity, making intelligent irrigation decisions based on real-time data. The system significantly optimizes water usage, reducing wastage and enhancing efficiency. With an automated decision-making process, it ensures that crops receive adequate water supply while minimizing human intervention. The quick response time of the system makes it highly effective in real-world applications, proving its suitability for sustainable and precision agriculture.

VI. CONCLUSION

The Smart Plant Monitoring System has successfully demonstrated an efficient, cost-effective, and automated approach to plant irrigation. It improves water efficiency, reduces manual labor, and enhances plant health through data-driven decision-making. The system addresses key agricultural challenges by using sensor-based automation, making it a viable solution for smart farming and home gardening.

While the project has achieved its core objectives, power supply dependency and internet connectivity limitations present areas for future improvement. Integrating renewable energy sources and IoT-based remote monitoring could further enhance the system's reliability and usability.

Overall, this project showcases the potential of smart agricultural solutions and lays the foundation for future advancements in automated irrigation and precision farming technologies

VII. ACKNOWLEDGMENT

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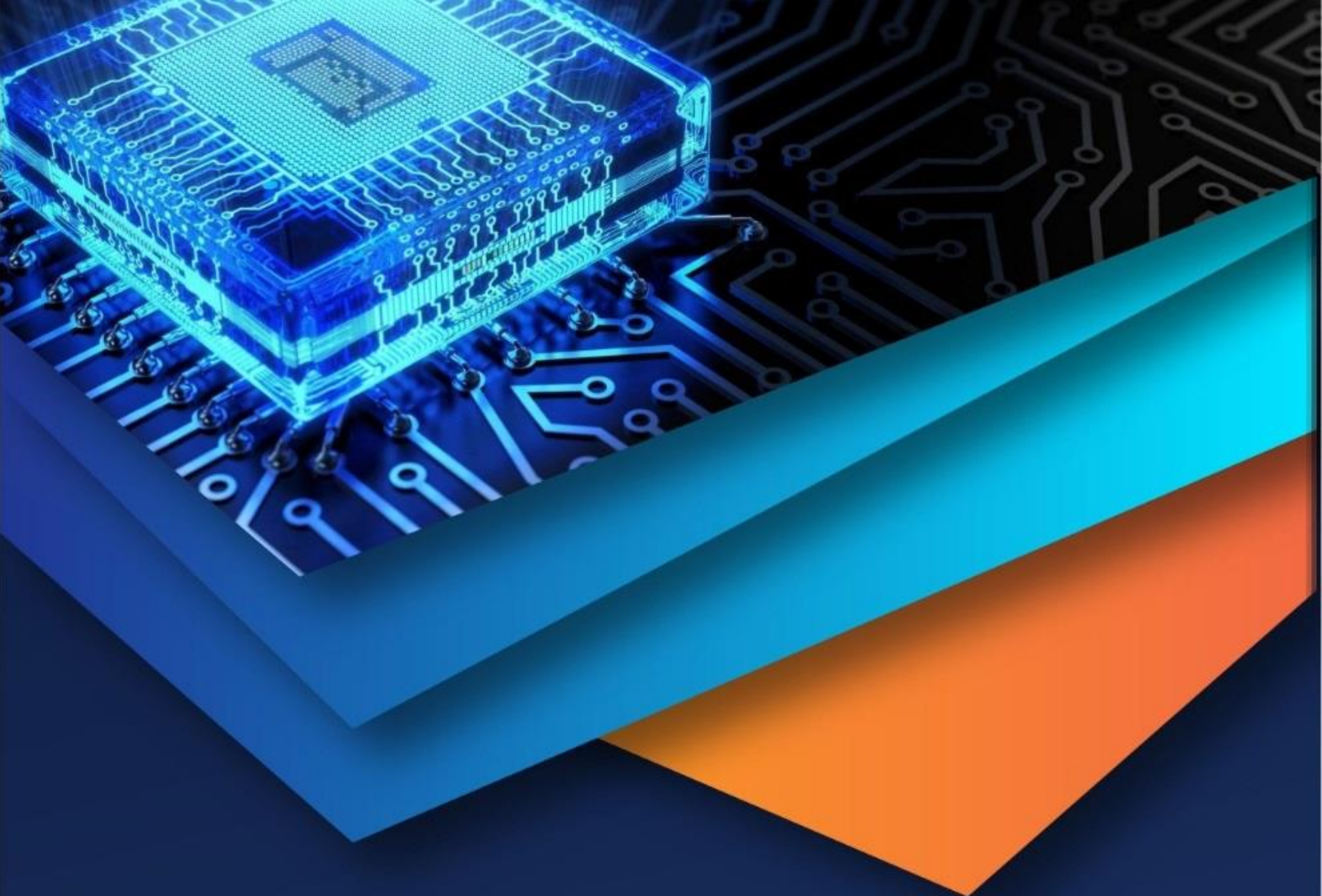

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