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Automatic Plant Watering System based on the Environmental Changes

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***Abstract*—Internet of Things (IoT) integration has caused a paradigm shift in conventional agricultural methods in the last few years. Using data collected from the surrounding environment, this project aims to create an APWS, or Automatic Plant Watering System, that will optimize plant care. The system includes sensors that track soil moisture, temperature, and humidity, all of which have a significant impact on the well-being and development of plants. By continuously analyzing these parameters, the APWS autonomously adjusts watering schedules to ensure plants receive adequate moisture levels tailored to their specific needs. A microcontroller serves as the central processing unit, interpreting sensor data and controlling the water supply mechanism. The implementation of IoT connectivity allows remote monitoring and management of the system via a user- friendly interface, enhancing convenience and efficiency. This project aims to promote sustainable agriculture practices by minimizing water wastage while maximizing crop yield through intelligent environmental responsiveness.**

***Index Terms*— IOT in agriculture, Automatic Plant watering System (APWS), Soil Moisture Monitoring, Environmental Data Optimization, Microcontroller, Remote Monitoring, Sustainable Agriculture, Water Management, Crop Yield Maximization, Intelligent Environmental Responsiveness.**

I. Introduction

The two primary components of the Internet of Things (IoT) are the "Internet" and the "Things." The "Things" that make up the Internet of Things are diverse and identity-enabled objects that can sense their environment, respond to actions, and track data in real-time. These Internet of Things gadgets have the ability to directly or indirectly share data with other linked devices and apps. Additionally, they are capable of gathering data, processing it, and sending it to other servers for additional analysis. An enormous number of computers and other devices all around the globe are linked via what is commonly known as the "Internet" to allow for the free flow of information. Therefore, IoT can be defined as a system that enables interconnected devices to communicate, collect, and exchange data via the internet, creating a network of smart devices capable of real-time interaction and automation.

“A dynamic Global Network Intra turn with self-configuring capabilities based on standard and inter operable communication to protocol where physical and virtual things have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network, often communicate data associated with user.” In a perfect world, an Internet of Things device would have many wired or wireless interfaces that allow it to connect to other devices.

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There are a few essential parts to every Internet of Things (IoT) device:

- Sensors' input/output interface.
- A means of accessing the Internet.
- Interface for Data Storage and Memory.
- Audio/Video Interface

A. IOT and Enabling Technologies

A number of critical technologies underpin the IoT, such as Wireless Sensor Networks (WSNs), Web Services, Security Protocols, Big Data, Embedded Systems, Cloud Computing, and the Internet.

- Wireless Sensor Networks (WSN): WSNs consist of interconnected sensors or nodes designed to gather and monitor diverse types of data.
- Cloud Computing: Cloud computing, sometimes called on-demand computing, is a method of storing and retrieving data and processing resources over the internet on an as-needed basis. A few examples of the services included in this category include software as a service (SaaS), infrastructure as a service (IaaS), and data as a service (DaaS).
- Big Data Analytics: This refers to analyzing massive, diverse data sets to discover hidden patterns, trends, and insights, offering significant value in business and technology.
- Communication Protocols: These protocols are essential in IoT systems, ensuring seamless data exchange by handling data formats, encoding, and addressing across networks.
- Embedded Systems: These systems are specialized computer setups combining hardware and software to perform dedicated tasks, including components like microcontrollers, memory, networking units, and I/O devices.

B. Overview of the Project

Based on the sensors it includes, this Internet of Things gadget is built to monitor environmental data in real-time, including humidity levels, temperature, and more. The system's "Plug & Sense" method makes it simple for farmers to use smart farming practices; all they need to do is deploy the device to the field and have access to real- time data updates on their smartphones or tablets. Through the integration of cloud computing, agricultural experts may remotely view and share the sensor data. The technology also allows for continuous data analysis using Big Data Analytics, which yields useful insights with time.

II. Literature Survey

In this survey authors Abdullah,M.,& Rahmat in the year 2020 reviews various smart irrigation systems leveraging IoT technology, focusing on sustainable agriculture. The study discusses how IoT-based systems perfect water usage by monitoring key environmental factors such as soil moisture, temperature, and weather conditions. It also addresses the challenges of integrating these technologies in different agricultural settings and proposes solutions for improving the scalability and cost effectiveness of smart irrigation systems. Improving water management efficiency is the primary focus of this research, which highlights the significance of collecting and analyzing data in real-time.

In this survey Ahmad, S., & Yaseen, M. in the year 2021 explores advancements in automatic irrigation systems that integrate environmental monitoring technologies. Several sensors that measure soil moisture, temperature, and other environmental factors are discussed, along with their role in improving irrigation system efficiency. Also included in the survey is the topic of using predictive models and machine learning algorithms to automate irrigation using four different types of environmental data.The paper highlights the potential of these systems to reduce water consumption and increase agricultural productivity while adapting to varying environmental conditions.

This research by Ali, M., and Zaman, F. provided a thorough overview of irrigation systems that relied on the Internet of Things in 2022, with an emphasis on how these systems were used in smart farming. The authors review the several types of sensors and communication technologies used in these systems, as well as their integration with cloud computing and big data analytics. Data security, system dependability, and scalability are some of the obstacles to using IoT in agriculture that are included in the report. Additionally, the paper explores the potential benefits of IoT-enabled irrigation systems, including improved water management, increased crop yield, and reduced labour costs.

In this review Bhatt, R., & Patel, S. in the year 2019 focuses on the use of soil moisture sensors in automatic irrigation systems. The authors discuss the several types of soil moisture sensors available, such as capacitive, resistive, and densiometric sensors, and their applications in agriculture. The paper highlights the importance of soil moisture monitoring in perfecting water use and preventing over- irrigation or under-irrigation. Additionally, the review covers the integration of these sensors with microcontrollers and IoT platforms to create automated irrigation systems that respond to real-time soil moisture data.

In this survey Chakraborty, A., & Das, S. provides an overview of smart irrigation systems in the year 2021 examining the current technologies used and suggesting future research directions. The paper discusses the role 5 of IoT, wireless sensor networks, and machine learning in developing automated irrigation systems that can adapt to environmental changes. It also explores the potential of integrating these systems with weather forecasting models to perfect irrigation schedules. The authors highlight the challenges of implementing smart irrigation systems on a large scale, including the need for standardized protocols, energy-efficient sensors, and reliable communication networks. The authors Deshmukh, P., & Jadhav, R. in the year 2020 reviewed automated irrigation control systems that are adaptable to environmental changes. They analyze the various technologies used, such as microcontrollers, sensors, and IoT, to create systems that naturally change water system plans in light of continuous ecological information. The paper discusses the benefits of these systems, including water conservation, reduced labor costs, and improved crop yield. The survey also explores the challenges of integrating these technologies in small-scale farming operations, such as cost, complexity, and the need for technical ability. In this paper Gupta, A., & Sharma, V. surveyed smart plant watering systems that utilize IoT and sensor networks in the year 2022. It reviews the several types of sensors used for monitoring soil moisture, temperature, and other environmental parameters, as well as their integration with IoT platforms for remote monitoring and control. The authors discuss the potential of these systems to improve water use efficiency and reduce the environmental impact of irrigation practices. The survey also highlights the challenges of implementing IoT-based plant watering systems, such as data security, system reliability, and the need for user-friendly interfaces. The authors Hussain, A., & Khan, S. in the year 2021 conducted a literature survey on automated irrigation systems, focusing on the use of environmental data to perfect irrigation schedules. The paper reviews various case studies and applications of these systems in precision agriculture, highlighting their potential 6 to reduce water consumption and increase crop yield. The survey also discusses the challenges of integrating environmental monitoring technologies with existing irrigation systems, such as cost, complexity, and the need for reliable data transmission. The authors also investigate how automated irrigation systems may be enhanced with the use of machine learning methods.

In this survey Iqbal, N., & Qureshi, M highlights IoT-enabled smart irrigation systems, with a focus on environmental monitoring in the year 2020. The authors discuss the various sensors used for measuring soil moisture, temperature, and humidity, and how these sensors are coordinated with IoT stages to give continuous information to water system the board. The paper additionally investigates the utilization of distributed computing and large information analytics to analyze environmental data and perfect irrigation schedules. The survey highlights the benefits of IoT-based smart irrigation systems, such as improved water use efficiency, reduced labor costs, and increased crop yield. The authors Jain, P., & Singh, R. in the year 2021 presented a systematic review of automatic irrigation systems that use environmental sensors. The paper discusses the diverse types of sensors used for monitoring soil moisture, temperature, and other environmental parameters, and their integration with microcontrollers and IoT platforms. The authors also review various algorithms and models used to automate the irrigation process based on environmental data. The survey highlights the potential of these systems to improve water use efficiency, reduce labor costs, and increase agricultural productivity. Additionally, the authors discuss the challenges of implementing these systems on a large scale.

III. PROPOSED METHODOLOGY

A. Component Selection

- Microcontroller: Choose a suitable microcontroller (e.g., Arduino, Raspberry Pi).
- Sensors: Select soil moisture sensors to monitor soil conditions.
- Water Pump: Choose an appropriate water pump for irrigation.
- Relay Module: Use a relay module to control the water pump.
- Power Supply: Ensure a stable power supply for all components.

B. Circuit Design

- Connect Sensors: Connect the soil moisture sensors to the microcontroller.
- Connect Relay: Connect the relay module to the microcontroller and the water pump.
- Power Connections: Ensure all components are properly powered.

C. Programming the Microcontroller

- Write Code: Develop code to read sensor data and control the water pump based on predefined thresholds.
- Set Thresholds: Define moisture thresholds for when to activate the water pump.
- Implement Logic: Implement logic to turn the water pump on and off based on sensor readings.

D. Testing and Calibration

- Initial Testing: Test the system with different soil moisture levels to ensure proper functioning.
- Calibration: Calibrate the sensors and adjust thresholds as needed for optimal performance.

E. Deployment

- Install System: Set up the system in the desired location (e.g., garden, greenhouse).
- Monitor Performance: Regularly monitor the system to ensure it operates correctly and make adjustments if necessary.

F. Optional Enhancements

- IoT Integration: Integrate with IoT for remote monitoring and control.
- Data Logging: Implement data logging to track watering schedules and soil moisture levels over time.

IV. ALGORITHM

Threshold-Based Algorithm: This algorithm uses predefined thresholds for soil moisture levels. When the soil moisture drops below the threshold, the system triggers the watering mechanism.
Predictive Algorithm: This algorithm uses historical data and environmental factors (like weather forecasts) to predict when the plants will need watering. It helps in optimizing water usage by anticipating the plant's needs.
Feedback Control Algorithm: This algorithm dynamically changes the watering schedule based on the soil moisture levels, which are monitored continually. By using real-time data, it guarantees that the plants are watered appropriately.
Fuzzy Logic Algorithm: This algorithm uses fuzzy logic to handle the uncertainty and variability in environmental conditions. It provides a more flexible and adaptive approach to watering plants.
Machine Learning Algorithm: Advanced systems may use machine learning algorithms to learn from past data and improve watering efficiency over time. These algorithms can adapt to different plant types and environmental conditions.

V. COMPONENTS USED

Microcontroller: Acts as the system's brain, processing sensor data and controlling the water pump. Examples include Arduino and Raspberry Pi.
Soil Moisture Sensor: Determines whether watering is necessary by measuring the soil's moisture level and relaying that information to the microcontroller.
Water Pump: Transports plant water via a reservoir pump. A microcontroller-based system that activates when soil moisture levels are detected.
Relay Module: The microcontroller can activate and deactivate the water pump with the help of this switch.
Power Supply: Provides electrical power to the entire system, ensuring all components function properly.
Tubing and Fittings: Connects the water pump to the plants, distributing water evenly to the root zones.

VI. SYSTEM ARCHITECTURE

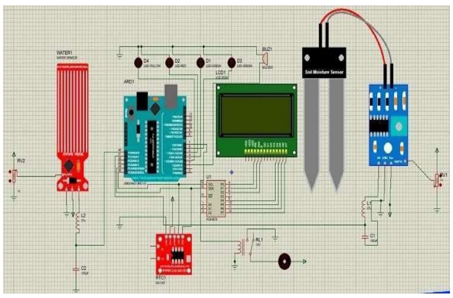

Figure-1 Circuit and Components

From Figure-1 The system architecture is explained as follows

A. Sensors Layer

- Soil Moisture Sensor: Detects soil moisture levels.
- Optional Sensors: May include temperature, humidity, and light sensors for additional data.

B. Control Layer

Microcontroller: Acts as the central unit, processing data from sensors and making decisions. Examples: Arduino, Raspberry Pi.

C. Actuator Layer

- Relay Module: Controls the activation of the water pump.
- Water Pump: Delivers water to the plants as instructed by the microcontroller.

D. Power Supply

- Power Source: Provides the necessary power to the sensors, microcontroller, relay, and water pump.

E. Communication Layer (Optional)

- IoT Module: Enables remote monitoring and control via a user interface, if integrated.

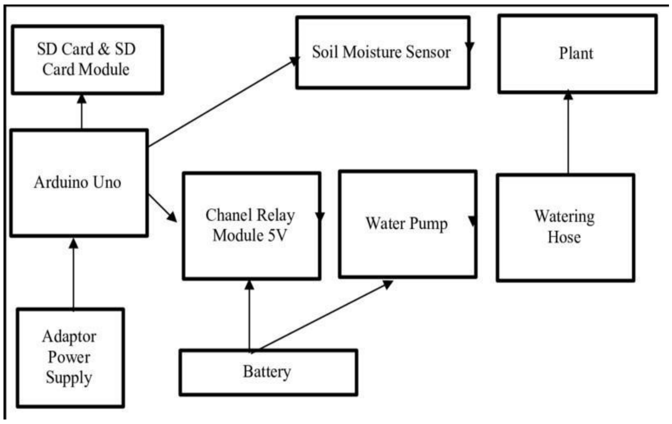

Figure-2 Block Diagram

F. Water Distribution System

- Tubing and Fittings: Directs water from the pump to the plants.

Advantages

Efficient Water Usage: The system ensures that plants are watered only when necessary by monitoring soil moisture, lessening water squander and advancing reasonable water use.
Real-Time Monitoring: Farmers or gardeners can monitor soil conditions and system activity in real-time on devices like smartphones or tablets, allowing for greater control and timely adjustments.
Automation and Convenience: The system automatically waters plants based on predefined soil moisture thresholds, eliminating the need for manual intervention and ensuring consistent plant care even when users are away.
Energy Efficiency: The use of a rechargeable battery and energy-efficient components like the Arduino Uno and DC motor keeps energy consumption low, making the system eco- friendly.
Customization: The system can be adjusted for different soil types, moisture thresholds, and plant needs, offering flexibility for a wide range of crops and environments.
Scalability: The system can easily be scaled up for larger agricultural setups by adding more sensors and devices, providing a versatile solution for farms of various sizes.
Data Logging and Analysis: With integration into cloud computing and big data analytics, the system can store and analyze historical data for better decision-making regarding plant health, watering patterns, and resource management.
Remote Access: The system allows users to manage and control watering from any location, offering convenience and flexibility, especially for large or remote farms.

Cost-Effective: By reducing water and labor costs, the system delivers long-term savings while maintaining optimal plant growth conditions.

Disadvantages

Initial Cost: Setting up the system can be costly due to the need for sensors, microcontrollers, and other components.

Maintenance: Regular maintenance is required to ensure the sensors and water distribution system remain functional.

Technical Knowledge: Building and programming the system requires a certain level of technical expertise.

Power Dependency: The system relies on a continuous power supply, which can be a limitation in areas with unreliable electricity.

Calibration: Sensors may need frequent calibration to maintain accuracy, which can be time-consuming.

Environmental Factors: External factors like extreme weather conditions can affect the system's performance.

VII. Results

Improved Plant Health: By providing consistent and best watering, plants are less likely to suffer from under or over- watering, leading to healthier growth.

Water Conservation: These devices may aid in water conservation by minimizing water waste and making sure plants only get the water they need.

Convenience: Users can save time and effort by automating the watering process, especially useful for those who travel often or have busy schedules.

Data Collection: Some systems collect data on soil moisture, temperature, and humidity, which can be used to further perfect watering schedules and improve plant care.

Using sensors, the device regularly checks the soil's moisture level. A signal is sent by the microcontroller to the relay module, which then operates the water pump, hydrating the plants if the moisture content falls below a certain threshold. There is an automated shutoff mechanism that activates when the soil moisture level reaches the set point. This automated process ensures that plants receive the appropriate amount of water according to real-time soil conditions, fostering healthier growth and efficient water use. Additionally, integrating IoT capabilities allows for remote management and monitoring, providing extra convenience and flexibility. Overall, the automatic plant watering system effectively maintains plant health, conserves water, and reduces the need for manual labor, making it an excellent solution for modern gardening and farming

References

[1] Ali, R., & Khan, Z. (2022). "Smart irrigation system using IoT and soil moisture sensors." Journal ofAdvanced Research in Engineering and Technology.

[2] Babu, A., & Joseph, S. (2023). "Climate-responsive automatic irrigation system using AI and IoT." Journal of Environmental Science and Technology.

[3] Chowdhury, M., & Das, A. (2021). "IoT-based automatic plant watering system for smart agriculture." International Journal of Computer Applications.

[4] Desai, K., & Patel, P. (2023). "Energy-efficient irrigation control using environmental monitoring." Journal of Sustainable Agriculture and Environment.

[5] Gupta, A., & Sharma, S. (2022). "Automatic irrigation system using environmental sensors and IoT." International Journal of Engineering Research and Technology.

[6] Hussain, M., & Ahmad, N. (2021). "IoT-based smart irrigation system with weather forecasting."

[7] Iqbal, M., & Raza, S. (2022). "Automatic plant watering system integrated with climate data."

[8] Jain, R., & Verma, P. (2023). "Design and implementation of an automated irrigation system using Arduino." International Journal of Agricultural Technology.

[9] Kumar, P., & Singh, A. (2023). "Adaptive irrigation system using IoT and machine learning." Journal of Smart Agriculture.

[10] Li, X., & Zhang, Y. (2022). "A novel automatic irrigation system for smart farming using sensors." Journal of Agricultural Research and Development.