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IoT-Based Plant Water Monitoring System

Mr. Mohanraj[1]*, V. Yuvaraj*[2]

[1]*Student, III-BCA-Department of Computer Applications, Dr. N.G.P. Arts and Science College, Coimbatore-641048*
[2]*Assistant Professor, Department of Computer Applications, Dr. N.G.P. Arts and Science College, Coimbatore-641048*

A B S T R A C T

The IoT-Based Plant Water Monitoring System is an innovative solution designed to automate irrigation and optimize water usage efficiently. This project addresses the challenge of overwatering and underwatering by continuously monitoring soil moisture levels and activating a water pump only when necessary. The system uses a soil moisture sensor to measure the water content in the soil and sends the data to an ESP8266 microcontroller, which processes the information and controls the relay-connected water pump. The moisture levels are displayed on an LCD screen in real-time, providing instant feedback to the user. Additionally, the system is integrated with the Blynk IoT platform, allowing remote monitoring via a smartphone application. Through the Blynk app, users can view live moisture readings and manage the irrigation system. This project leverages IoT technology to promote water conservation by ensuring that plants receive only the necessary amount of water, reducing waste and preventing waterlogging. The automated irrigation process reduces manual intervention, making it ideal for home gardens, greenhouses, and agricultural farms. The system also offers flexibility by allowing users to set customizable moisture thresholds, adapting to different plant needs.

Keywords: IoT, Plant Water Monitoring, Smart Irrigation, Soil Moisture Sensor, ESP8266, Automation.

1. Introduction

The importance of efficient water management in agriculture cannot be overstated. With the global population projected to reach 9.7 billion by 2050, the demand for food production is increasing exponentially, putting a strain on the world's water resources. Moreover, climate change is altering precipitation patterns, leading to more frequent droughts and floods, which can have devastating effects on crop yields. In this context, precise monitoring and management of water resources are crucial for ensuring optimal crop health, reducing waste, and promoting sustainable farming practices.

Traditional irrigation methods, which rely heavily on manual monitoring and guesswork, are no longer sufficient to meet the challenges of modern agriculture. Overwatering and underwatering are common problems that can lead to reduced crop yields, decreased water quality, and increased energy consumption. Furthermore, the lack of real-time data on soil moisture levels, temperature, and humidity makes it difficult for farmers to make informed decisions about irrigation scheduling.

To address these challenges, the development of innovative technologies that enable precise monitoring and management of water resources is essential. This is where the Plant Water Monitoring System comes in – a cutting-edge technology designed to provide real-time insights into soil moisture levels. By leveraging advanced sensor technologies and wireless communication protocols, this system enables farmers and growers to optimize irrigation schedules, reduce water consumption, and promote healthy plant growth.

1.1 Problem Identification

Conventional irrigation systems suffer from inefficiencies that lead to water wastage, increased costs, and inconsistent crop yields. The lack of real-time monitoring makes it difficult for farmers to determine precise water requirements, often resulting in overwatering or underwatering. The proposed IoT-based solution automates irrigation by integrating soil moisture sensors, a microcontroller, and wireless connectivity. This system enhances resource efficiency, reduces labor costs, and ensures precise water management. Section headings

1.2 Components Description

SOFTWARE TOOL:(Arduino IDE)-Nightly

Arduino IDE (Integrated Development Environment) is an open source software platform used for programming Arduino microcontroller boards. It provides a user-friendly interface and a set of tools that allow users to write, compile, and upload code to Arduino boards easily. supports a simplified version of C/C++ language.

Arduino IDE has a simple interface, making it accessible to students, and professionals. The code editor provides syntax highlighting, auto-completion, and error checking to assist users in writing code efficiently. Arduino IDE includes a compiler that translates the code written in the IDE into machine-readable instructions (binary code) that can be understood by the Arduino board's microcontroller. This process is crucial for creating programs that can control various hardware components connected to the Arduino. Once the code is written and compiled, Arduino IDE facilitates the upload process, sending the compiled code to the Arduino board via a USB connection. This allows users to test their programs and interact with connected sensors, actuators, displays, and other electronic components.

Arduino IDE 2.3.4 introduces several new features that enhance the overall development experience. One notable feature is the improved code editor, which offers enhanced syntax highlighting, auto-completion, and code folding.

.Additionally, the IDE now supports multi-board programming, allowing users to connect and program multiple Arduino boards simultaneously. The serial plotter feature enables users to visualize serial data in real-time, making it easier to debug and analyze projects.in exchange for early access to features, the Arduino IDE Nightly provides an invaluable platform for experimentation and innovation.

Here's some more information about the Arduino IDE 2.3.4 :

Improvements

Arduino IDE 2.3.4 also includes several improvements that address user feedback and enhance the overall stability of the IDE. One significant improvement is the faster compilation speed, which enables users to develop and test their projects more quickly. The IDE also features better error handling, providing more informative error messages and debugging tools. Furthermore, the IDE's stability has been improved, reducing the occurrence of crashes and errors.

Supported Boards

Arduino IDE 2.3.4 supports a wide range of Arduino boards, including the popular Arduino Uno, Mega, and Nano. The IDE also supports more advanced boards like the Arduino Due and Portenta. Additionally, the IDE supports third-party boards, such as the ESP32 and ESP8266, making it a versatile tool for developing a broad range of projects.

2. System Requirements

To run Arduino IDE 2.3.4, users will need a computer with a 64-bit processor, 4 GB of RAM, and 500 MB of available disk space. The IDE is compatible with Windows 10 or later, macOS 10.12 or later, and various Linux distributions.

2.1 HARDWARE/PHYSICAL COMPONENTS:

Node MCU ESP8266:

The ESP8266 NodeMCU CP2102 WiFi Development Board is a microcontroller board designed for IoT projects, featuring a Tensilica 32-bit RISC CPU, 4MB flash memory,and 64KB SRAM. It operates at 3.3V, with an input voltage range of 7-12V, and provides 16 digital I/O pins, 1 analog input pin, and various communication interfaces, including UART, SPI, and I2C. The board is programmable using the Arduino IDE.

SOIL MOISTURE SENSOR:

Soil moisture sensor is used to detect the moisture of the soil. This sensor is made up of two pieces: the electronic board at the right, and the probe with two pads, that detects the moisture content The voltage of the sensor outputs changes accordingly to the moisture level in the soil. When the soil is: Wet: The output voltage decrease Dry: The output voltage increase.

5V 10A Relay Module:

A relay module is an electrical device that serves as a switch to control the flow of electrical current to a connected device, allowing for the automation of various applications. Its main functionality includes switching and control, isolation and protection, signal amplification, automation and remote control, overload protection, timing and scheduling, monitoring and feedback, and multi-channel control. Relay modules can switch on/off, or toggle, the electrical supply to a connected device, enabling control over its operation. They provide electrical isolation between the control circuit and the connected device, protecting against voltage spikes, surges, and electrical noise. Additionally, relay modules can amplify low-voltage signals from microcontrollers or other control devices to control high-voltage or high-current devices.

3V to 9V Mini DC Submersible Pump

Mini DC submersible pumps operating within the 3V to 9V range are designed for efficient water movement and are suitable for aquariums, hydroponic systems, small fountains, and DIY projects. These pumps are compact, lightweight, and offer a flow rate of up to 120 L/H, with a maximum lift of 40-110 mm.

LCD DISPLAY:

A 16x2 LCD display is a type of liquid crystal display that shows 2 lines of text, with each line capable of displaying 16 characters, used for displaying text, numbers, and symbols in various application.

I2C Serial Interface LCD Adapter Module:

I2C (Inter-Integrated Circuit), also known as

IIC, is a widely used, synchronous, multi-master/multi-slave, single-ended serial communication bus protocol that uses two wires, SDA (Serial Data) and SCL (Serial Clock), for short-distance communication

9V Battery

A 9V battery provides a stable 9-volt power source to devices, enabling them to function, operate, and perform their intended tasks.

2.2. Software Components

- Arduino IDE – Used for programming the ESP8266 microcontroller.

- Blynk Platform – Allows remote monitoring and control via a mobile application.

2.3. System Flow and Operation

1. The soil moisture sensor collects real-time moisture data.

2. The ESP8266 processes the sensor data and determines whether irrigation is required.

3. If moisture levels fall below a predefined threshold, the relay module activates the water pump.

4. The LCD display updates soil moisture values, and the Blynk app provides remote access.

5. Once adequate moisture is detected, the pump is deactivated to prevent overwatering.

- Power Supply Check – Verifying proper voltage supply to all components.

- Sensor Accuracy Test – Comparing soil moisture readings with actual conditions.

- Relay and Pump Operation – Ensuring correct activation and deactivation based on moisture levels.

- WiFi Connectivity Test – Checking real-time data transmission via the Blynk app.

3. PROTOTYPE DESCRIPTION

This prototype outlines a basic IoT plant water monitoring System designed for irrigation growth. The system utilizes several key components:

- **NODE MCU ESP8266:** Node MCU ESP8266Enables Wi-Fi connectivity for remote monitoring.
- **SOIL MOISTURE SENSORS:** Soil Moisture Sensor Monitors soil moisture levels in real-time.
- **RELAY MODULE:** Relay Module Controls water pump activation/deactivation. LCD Display Displays soil moisture levels and system status.
- **DC MOTOR:** Water Pump Automatically waters plants based on moisture levels.
- **LCD SCREEN:** LCD Display Displays soil moisture levels and system status
- **Battery:** A battery provides power to the motor.

Hardware Integration:

The hardware integration involves connecting the soil moisture sensor to the ESP8266 board's analog input pin, the relay module to the digital output pin, and the 16x2 LCD display to the I2C pins. The 9V battery provides power to the system, and the ESP8266 board serves as the brain of the operation.

Microcontroller and Algorithm:

The microcontroller (ESP8266) serves as the central processing unit. It continuously collects data from the soil moisture sensor. A soil moisture monitoring algorithm on the microcontroller analyzes this data for moisture levels below a predetermined threshold, and accordingly controls the relay module to activate or deactivate the water pump.

Module Connectivity

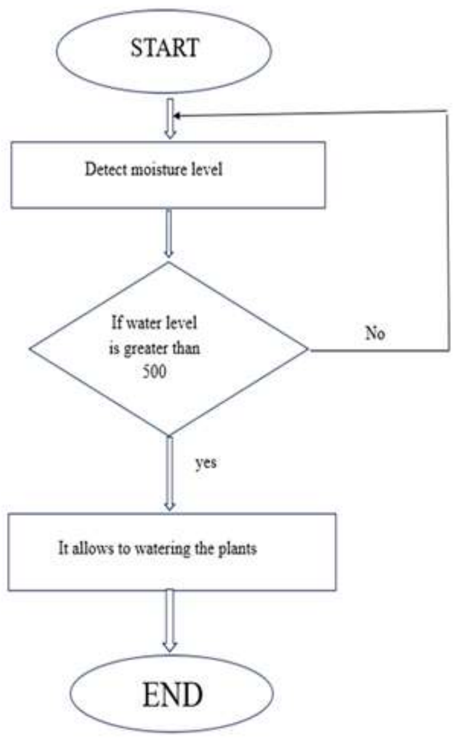
I2C Module	ESP8266
SDA	D2
SCL	D1
VCC	3.3V
GND	GND

Soil Moisture Sensor	ESP8266
VCC	3.3V
GND	GND
A0(Analog output)	A0

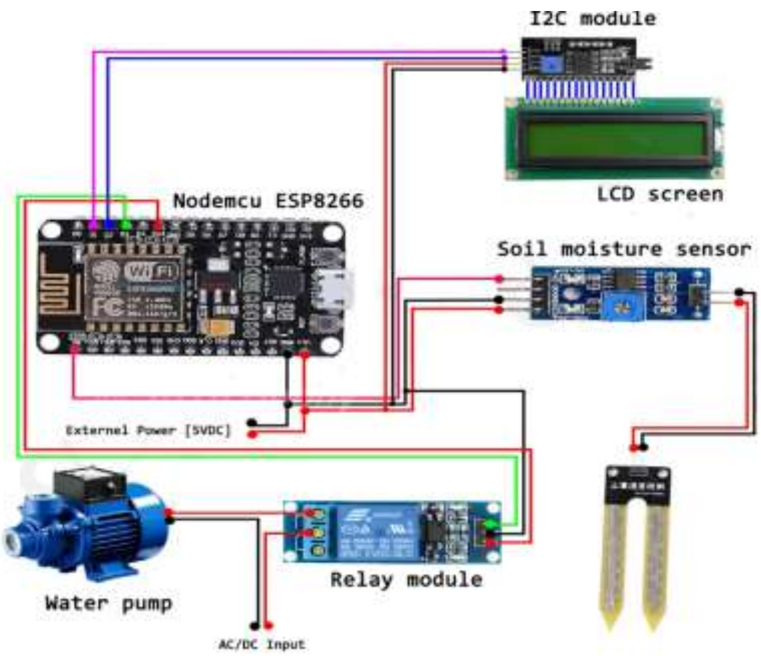
Water pump	Relay Module
Power Input	AC/DC
Live Wire	NO
Neutral Wire	Power Supply

External Power	ESP8266 & Other Components
5V	ESP8266
5V	Relay Module

5V	Other 5V component
GND	Common Ground for All Component



Circuit Diagram



Circuit Diagram of Plant Water Monitoring System

PROTOTYPE IMPLEMENTATION

IMPLEMENTATION OF LOGIC & OPERATIONS

Hardware Setup:

The **Plant Water Monitoring System** is built using the **ESP8266 (NodeMCU)** microcontroller, which connects to various sensors and actuators to automate the watering process based on soil moisture levels. The hardware components used in the system are integrated to ensure seamless communication and operation.

Arduino Sketch Logic:

- Define Blynk Credentials – Set up Blynk Template ID, Name, and Authentication Token for cloud connectivity.
- Include Required Libraries – Add Wire.h, LiquidCrystal_I2C.h, and BlynkSimpleEsp8266.h for hardware and cloud communication.
- Connect to WiFi – Define WiFi SSID and Password to connect ESP8266 to the internet.
- Initialize LCD Display (16x2) – Set up I2C communication and enable LCD backlight for displaying sensor values.
- Define Sensor & Relay Pins – Assign Soil Moisture Sensor to A0 and Relay to D7, with an adjustable moisture threshold.
- Setup Function – Start Serial Monitor, connect to Blynk, initialize LCD, and set relay OFF initially.
- Loop Function – Continuously read soil moisture, display data on LCD, and send it to the Blynk app (Virtual Pin V0).
- Check Soil Moisture Level – Compare moisture value with the threshold (500) to decide whether to activate or deactivate the pump.
- Control Water Pump – If soil is dry, turn relay ON (start watering). If moist, turn relay OFF (stop watering).
- Delay for Stability – Use a 1-second delay to ensure smooth and periodic updates.

Operation Overview:

The Automated Plant Watering System is an IoT-based project that utilizes sensors and microcontrollers to automate plant watering, ensuring optimal plant health and water conservation. The system consists of an ESP8266 microcontroller, soil moisture sensor, relay module, I2C LCD display, and Blynk platform. The soil moisture sensor monitors soil moisture levels and sends data to the ESP8266 microcontroller, which processes the data and determines if watering is necessary. If watering is necessary, the ESP8266 microcontroller sends a signal to the relay module to activate the water pump, which waters the plants until the soil moisture levels reach the optimal range.

Testing and Validation:

- Power Supply Check – Ensure the ESP8266, LCD, soil moisture sensor, and relay module receive the correct voltage (3.3V/5V).
- WiFi Connection Test – Verify ESP8266 successfully connects to the configured WiFi network.
- LCD Display Test – Ensure the LCD correctly initializes and displays sensor values.
- Soil Moisture Sensor Test – Check if the sensor provides correct analog readings in dry and wet conditions.
- Relay & Water Pump Test – Manually trigger the relay to confirm it turns the pump ON/OFF.
- Serial Monitor Debugging – Check real-time sensor values and system status messages.
- Blynk Cloud Data Transmission – Verify that sensor readings are transmitted to the Blynk app (V0).
- System Stability Check – Run the system continuously for extended periods to ensure reliable operation.

CONCLUSION

The Plant Water Monitoring System project embodies a paradigm shift in the realm of precision agriculture and IoT-driven plant care. By harnessing the power of advanced technologies, this project has yielded a sophisticated and efficient system for monitoring and regulating soil moisture levels, thereby ensuring optimal plant growth and water conservation.The project's groundbreaking approach and significant impact have far-reaching implications for a diverse range of stakeholders, including agricultural practitioners, horticultural experts, and environmental advocates. By providing real-time insights and automated watering capabilities, this project has the potential to revolutionize plant care practices, mitigating water waste, enhancing crop yields, and promoting sustainable agricultural methodologies.

As the global community continues to navigate the complexities of climate change, water scarcity, and food security, the Plant Water Monitoring System project emerges as a beacon of innovation and sustainability. Its transformative potential and capacity to drive positive change render it an exemplary model for future IoT-based initiatives and projects.

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