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Automatic Plant Watering System With IOT For Monitoring and Controlling Soil Moisture

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ABSTRACT

An automatic plant watering system based on the Internet of Things (IoT) was developed to make it easier to monitor and control soil moisture at home. The system combines a variety of technologies, including a soil moisture sensor, ESP32, Raspberry Pi, relays, water pump, and Node-RED. The moisture sensor measures soil moisture content and sends data to the ESP32. The ESP32 then sends that data via MQTT to the Raspberry Pi, which decides whether the pump needs to be activated. The relay, controlled by the Raspberry Pi, regulates power to the pump to water the plants as needed. Node-RED is used to create an interface that allows users to monitor and control the system in real-time, as well as perform manual control. With this system, watering plants becomes more efficient, reduces the need for manual intervention, and ensures ideal soil moisture for house plants. This technology shows great potential in smart home applications, offering a smarter and more efficient way to care for plants at home.

INTRODUCTION

With advancements in knowledge, particularly in electronics and communication, human lifestyles have also transformed. People now seek a more comfortable, efficient, and safe life. This has led to the emergence of the concept of smart homes, which allows for the automatic control of household devices remotely via internet connectivity. These systems are designed to make it easier and more convenient for homeowners to manage their homes. However, the penetration of smart home technology in Indonesia remains low due to factors such as high device costs, uneven internet access, and a lack of understanding about the concept and benefits of smart homes.

On the other hand, the Internet of Things (IoT) aims to expand the benefits of continuous internet connectivity. IoT refers to uniquely identifiable objects as virtual representations within an internet-based structure. It operates through automatic interactions between connected machines without user intervention. The internet serves as the link between these machine interactions, while users act only as managers and supervisors of the devices. The benefits of IoT include faster, easier, and more efficient work processes. A practical application of this concept is the automated plant irrigation system.

The automated irrigation system uses IoT for monitoring and controlling soil moisture. IoT technology automates the irrigation process based on soil moisture levels. Moisture sensors detect water content in the soil and send data to IoT devices, such as microcontrollers. These devices then process the data and activate the irrigation system automatically when soil moisture reaches a predetermined threshold. Based on this, the author presents the final project title “Automated Plant Irrigation System with IoT for Monitoring and Controlling Soil Moisture”.

LITERATURE REVIEW

The Internet of Things is a scientific development that is very promising for optimizing life based on smart sensors and smart equipment that work together via the internet network. Internet of Things (IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity that allows us to connect machines, equipment and other physical objects with networked sensors and actuators to obtain data and manage their own performance, making it possible machines to collaborate and even act on new information obtained independently. The benefit obtained from the IoT (Internet of Things) concept is that the work done can be faster, easier and more efficient. The basic system of IoT consists of 3 things, namely: Hardware/physical (Things), Internet Connection and Cloud Data Center where to store or run the application. In short, it can be said that the Internet of Things is where objects around us can communicate with each other via an internet network. The way the Internet of Things works is by utilizing a programming argument where

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each argument command produces an interaction between machines that are connected automatically without human intervention and at any distance. The internet is the link between the two machine interactions, while humans only serve as regulators and supervisors of the working of these tools directly.

MQTT (Message Queuing Telemetry Transport) is a protocol that runs on top of TCP/IP, designed specifically for machine-to-machine devices that do not have a dedicated address, such as an Arduino or Raspberry Pi. MQTT works with a publish and subscribe mechanism through a broker that manages data exchange between devices. Examples of frequently used brokers include Mosquitto and HiveMQ, where data published by sensor devices is sent to subscribers via specific topics.

Node-RED is a browser-based tool that allows users to create IoT applications visually through flow programming. The platform is easier to use than traditional text-based programming, facilitating rapid and efficient prototype development and IoT integration. Meanwhile, Node.js is a JavaScript-based platform used to build web and server-based applications. With a built-in HTTP server library, Node.js makes it possible to create web servers without the need for additional tools like Apache or Nginx.

Arduino IDE, developed from the Java language, is a programming tool used to write, upload and run programs on microcontrollers such as the ESP32. The program written is called "sketch" and is facilitated with an easy-to-use user interface. Telegram, a messaging application, can also be integrated with IoT through bots that enable automatic interaction with connected devices, providing flexibility and security in remote control systems.

In this IoT system, several hardware components used include the ESP32 as the main controller, a soil moisture sensor to monitor soil moisture, a Raspberry Pi as a mini server, and a water pump and relay to control the flow of water and electricity. The integration of these various components allows automatic monitoring and control based on data collected by sensors.

ESP32 is a microcontroller introduced by Espressif Systems as the successor to the ESP8266. ESP32 is known for its low cost and low power consumption, equipped with built-in WiFi and Bluetooth modules. In addition, ESP32 is very flexible because it can be used as a standalone system or as a supporting device for other microcontrollers. ESP32 is available in 30 and 36 GPIO versions, with the 30 GPIO version being more commonly used because it has two GND pins. This board is equipped with a USB-to-UART interface that makes programming easier using platforms such as Arduino IDE. ESP32 supports various pin functions such as GPIO, ADC, DAC, I2C, SPI, and UART, and supports 802.11 b/g/n Wi-Fi connectivity and Bluetooth.

Soil Moisture Sensor is used to measure the water content in the soil, which is very important for maintaining soil moisture in certain plants. The working principle of this sensor is by using two plates which, when exposed to water, will allow electrons to move, thus producing a current. Changes in soil conditions will affect the sensor output voltage, where wet soil will produce a lower voltage than dry soil.

Raspberry Pi is a single board computer that functions as a mini server in this system. The Raspberry Pi 3 Model B+ has many advantages over its predecessors, including a faster processor, better networking capabilities with dual-band Wi-Fi and Bluetooth support, and more efficient temperature management. The Raspberry Pi is equipped with 40 GPIO pins that allow for interfacing with various external devices. Some GPIO functions include power pins, SPI communication, I2C, and serial pins for communicating with other devices.

METHOD

Before starting the equipment manufacturing process, several design steps need to be taken to ensure that the equipment functions properly and aligns with the designed system. First, a block diagram should be created to illustrate the relationships between the components within the system. Next, a flowchart is developed to detail the operational steps, including the conditions necessary to activate the water pump based on data from the soil moisture sensor. Finally, the hardware circuit assembly stage is carried out by assembling all components, such as the moisture sensor, microcontroller, relay module, and water pump, according to the established design. By following these steps, the equipment manufacturing process can proceed smoothly and result in an optimal system as outlined below:

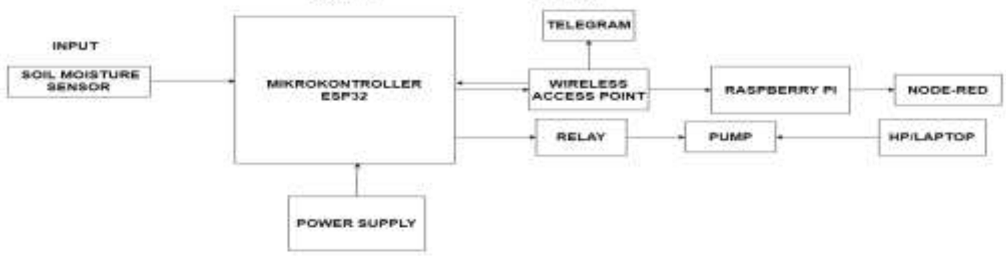

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Fig.1 Block Diagram

The diagram shows an automatic irrigation system using an ESP32. The system starts with a soil moisture sensor that measures how wet or dry the soil is. The data from this sensor is sent to the ESP32, a device that processes this information. If the soil is too dry, the ESP32 sends a command to activate the relay, which turns on the pump to water the plants. The system is also connected to a Raspberry Pi, working with Node-RED to monitor and control the irrigation.

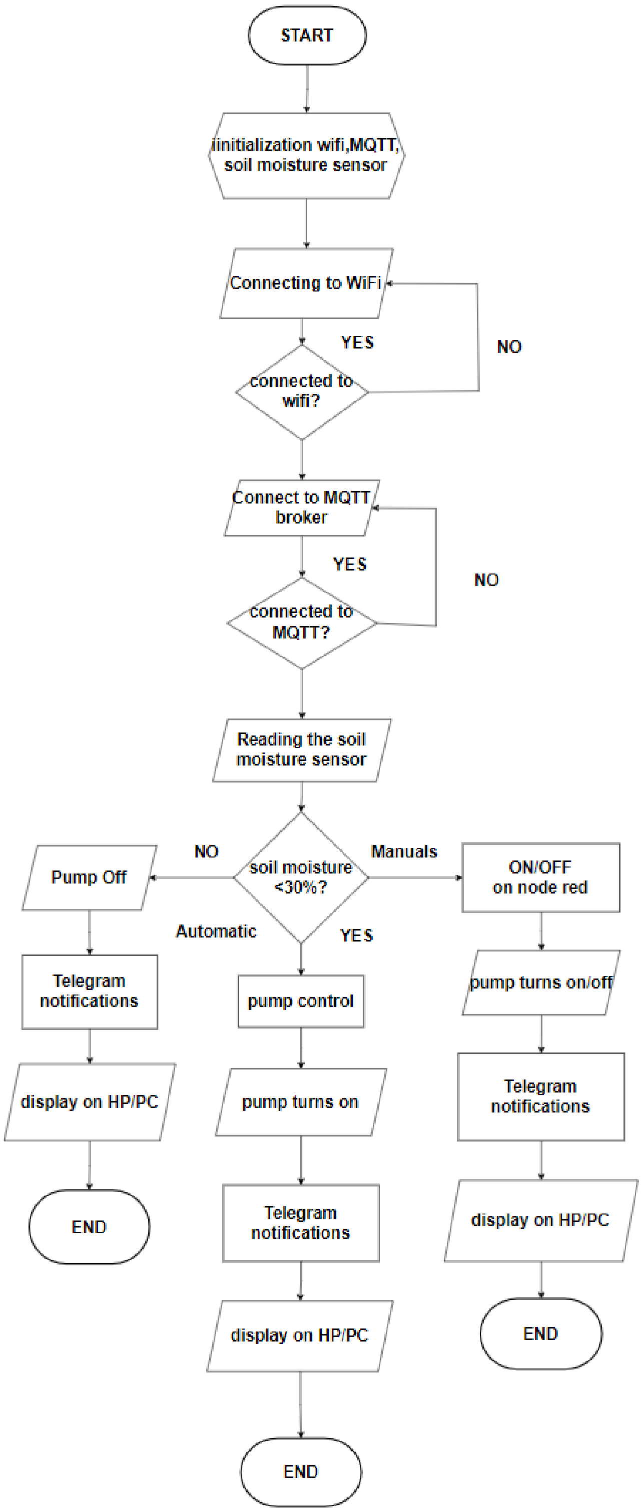

Fig. 2 Flowchart

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The flowchart of "automated plant system with iot for soil moisture monitoring and control" depicts the workflow involving the soil moisture sensor, ESP32, and data communication. The process begins with hardware initialization, followed by the connection of the ESP32 to Wi-Fi and the MQTT broker. Sensor. Soil moisture data is read periodically, which is then processed by the ESP32 to determine whether the pump should be activated or turned off based on a preset threshold. Users can control the pump manually via Node-RED or receive status notifications via Telegram humidity into the Node-RED dashboard for real-time monitoring

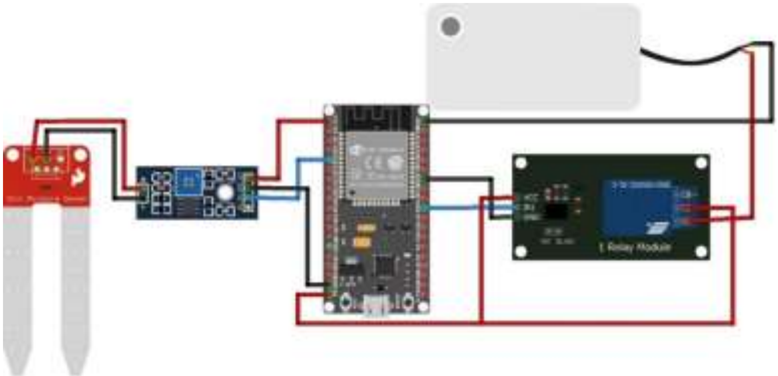

Fig. 3 Overall Planning Design

Table 1 PIN Connection on ESP32

No.	Pin ESP32	Connection
1.	GND	GND (Soil Moisture Sensor, Relay, Pump)
2.	D5	IN Relay
3.	D34	D0 Soil Moisture Sensor
4.	3/5v	VCC (relay, Soil Moisture Sensor)

RESULT

System testing is a step to find out whether the system created is as planned and in accordance with theory or not, if it is not in accordance with theory then the cause of the difference can be identified. Testing is carried out on each design block in the system. Before taking measurements, first prepare the tools needed to carry out the measurement process. The equipment needed includes water, plants, USB cable and laptop.

This test is carried out to find out whether the ESP32 used is connected to the internet network, by checking using the AT command on the serial monitor as in Fig. 4 below:

Fig. 4 Connection Display on Serial Monitor

Internet of Things (IoT) platform testing was carried out using Telegram and the Node-RED Dashboard. Data from the ESP32 is sent to Telegram, with the cellphone as the notification recipient. When the ESP32 is connected to a WiFi network, data regarding soil moisture and water pump status (ON/OFF) is sent in real-time to Telegram, so users can monitor these conditions. Soil moisture sensors monitor humidity in real-time, with data sent via the MQTT protocol

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and displayed on the Node-RED Dashboard. Tests were carried out to ensure the accuracy of soil moisture sensor measurements. The Node-RED dashboard displays soil moisture monitoring status, as well as providing manual and automatic control for plant watering based on moisture levels. The display of test results using Telegram and the Node-RED Dashboard can be seen in table 2 and figure 5.

Table 2 Soil Moisture Sensor Test Results on Telegram

Test	Detecting Soil Moisture	Telegram Notifications	Water pump	Time to Send Notification
1	Soil moisture 0%	Soil moisture below 0% water pump is ON	ON	2 Sec
2	Soil moisture 30%	Soil moisture below 30% water pump ON	ON	2 Sec
3	Soil moisture 70%	Soil moisture above 70% water pump OFF	OFF	2 Sec
4	Soil moisture 100%	Soil moisture 100% water pump OFF	OFF	2 Sec

Fig. 5 Node-Red Dashboard display

DISCUSSION

Various tests and measurements for this system have been carried out, both hardware and software. The results obtained are basically in accordance with the initial design results. On the input device, testing begins with a soil moisture sensor which is used to maintain plant humidity. The sensor detects plant humidity accurately to ensure that the system can respond appropriately to changes in plant humidity. If the soil moisture sensor provides inaccurate data, the system will not be able to control the water pump properly. Based on the test results, it can be concluded that the soil moisture sensor works very well and is able to provide accurate input to the ESP32 for further processing.

Furthermore, testing and measurement of output devices (Output) have also been carried out, both hardware (Hardware) and software (Software). The performance of each component provides maximum results or as desired. Execution by ESP32 of a water pump which functions as a soil moisture control device which has been functioning properly.

In the first experiment, the test was carried out with dry soil with soil moisture below 0%. As a result, the water pump automatically turns on and the Node-RED dashboard displays the "PUMP [ON]" indicator. Figure 6 shows the first test output display on the Node-RED dashboard.

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Fig. 6 Node-RED Dashboard Output Display in First Test

In the second experiment, the test was carried out by adjusting the soil moisture and activating the water pump manually via the Node-RED dashboard when the soil moisture reached 100%. Figure 7 shows the output display on the Node-RED dashboard when carrying out manual testing

Fig. 7 Node-RED Dashboard Output Display in Manual Testing

And in figure 8 is a display of notifications received on Telegram when the pump is activated manually.

Fig. 8 Manual Testing Telegram Notification Output Display

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CONCLUSION

This automatic plant watering system combines a soil moisture sensor, ESP32, raspberry pi, relay, water pump and Node-RED. The sensor measures soil water content and sends data to the ESP32 then forwards the information via MQTT to the raspberry pi. The Raspberry Pi determines watering needs and controls relays to activate the pump as needed. This system is automatic and effective in managing plant watering.

Internet of Things (IoT) technology in this plant watering system allows real-time monitoring of soil moisture and direct notification to users via Telegram if soil moisture decreases below a set limit. Ensure accurate and responsive watering management, maintaining optimal soil conditions

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