Smart irrigation system using node microcontroller unit ESP8266 and Ubidots cloud platform

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Article Info

Article history:

Received Mar 23, 2024
Revised Apr 28, 2024
Accepted May 12, 2024

Keywords:

Internet of things
Irrigation
Node microcontroller unit
Smartphone
Ubidots

ABSTRACT

The agricultural irrigation system is extremely important. For optimal harvest yields, farmers must manage rice plant quality by monitoring water, soil, and temperature on agricultural fields. If market demand rises, traditional rice field irrigation in Indonesia will make things harder for farmers. This modern era requires a system that lets farmers monitor and regulate agricultural fields anywhere, anytime. We need a solution that can control the irrigation system remotely using an internet of things (IoT) device and a smartphone. This study employed the Ubidots IoT cloud platform. In addition, the study uses soil moisture and temperature sensors to monitor conditions in agricultural regions, while pumps function as irrigation systems. The test results indicate the proper design of the system. Each trial collected data. The pump will turn on and off automatically based on soil moisture criteria, with the pump active while the soil moisture is less than 20% and deactivated when the soil moisture exceeds 20%. In simulation mode, the pump operates for an average of 0–5 seconds of watering. The monitoring system shows the current soil temperature and moisture levels. Temperature sensors respond in 1-3 seconds, whereas soil moisture sensors respond in 0–4 seconds.

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1. INTRODUCTION

Agriculture and food are two of the most important industrial sectors in the world, including in Indonesia. As an agricultural country, agriculture has a major impact on food security and the welfare of the Indonesian people. In an effort to obtain optimal agricultural results, it is necessary to pay attention to various aspects that support plant growth, one of which is good irrigation. Irrigation is an effort to provide and regulate water artificially from available water sources on agricultural land. Plants receive water on a regular basis, particularly when the soil lacks sufficient water to meet their growth needs. The main purpose of the irrigation system is to ensure that plants can grow well and produce optimal agricultural products.

Conventional irrigation systems are extremely time-consuming and require a lot of labor to monitor land conditions on a regular basis. The time and labor required to manage an irrigation system increase in proportion to the land area [1]. Conventional irrigation systems lack automatic control, which can lead to over- or under-irrigation, hindering optimal plant growth or even causing plant death. Aside from that, there are vital elements that plants need in managing the irrigation system, such as temperature and soil moisture. Conventional agriculture still manually monitors soil temperature and moisture, and irrigates rice [1]–[6].

Therefore, to ensure effective and efficient irrigation, we need a smart irrigation system that we can control remotely, either automatically or manually.

Smart irrigation systems can be built by utilizing electronic devices that are integrated with software systems with algorithms that have been prepared according to needs. Researchers have widely used AI-based intelligent algorithms in various fields, including smart agriculture [4], [5], [7]–[13]. Conversely, researchers have extensively explored the use of IoT technology for remote control and monitoring researchers [1], [5], [7]–[9], [11]–[15], [16]–[20]. Smart agricultural systems widely use IoT technology due to its ability to perform real-time monitoring and control remotely [5], [7], [8], [21]–[26].

Silalahi *et al.* [11] build a prototype using Raspberry Pi and Python-based internet of things. The goal of this research is to develop a new model for monitoring and controlling rice fields, with the ability to display each condition using the internet of things. The study by Guzman *et al.* [19] suggests that we should create and implement an Internet of Things (IoT) monitoring system for greenhouses. This would allow small-scale environmental control by understanding how the different agroecological variables affect the process. This would allow us to come up with different ways to control the variables of lighting, nutrition, and irrigation.

Krishnan *et al.* [13] proposed a smart irrigation system that helps farmers irrigate their agricultural land using the global system for mobile communications (GSM). This system provides acknowledgment messages about work status, such as soil moisture level, ambient temperature, and motor status regarding main power supply or solar power. Amassmir *et al.* [15] proposed a comparison of three machine learning algorithms for better intelligent irrigation systems based on the Internet of Things (IoT) for different products. This paper uses an Arduino UNO and a Raspberry Pi as hardware components. We use the Digital Humidity and Temperature (DHT) 11 as both a temperature and humidity reader and a soil moisture sensor to determine the irrigation status.

Monitoring soil moisture, air temperature, and automatic watering systems are the main parts of a smart irrigation system. A relevant sensor, processor, and actuator system are required for this system's design. This research proposes an irrigation system capable of monitoring soil moisture, temperature, and an automatic watering system. There are several sensors, such as DHT22 and soil moisture sensors, placed in agricultural areas. Furthermore, the Ubidots application will receive the sensor data and store it in a cloud database. Users receive the processed data on agricultural land conditions. We use ESP8266 as a data processor and to automatically control the irrigation system.

2. PROPOSED AUTOMATIC IRRIGATION SYSTEM

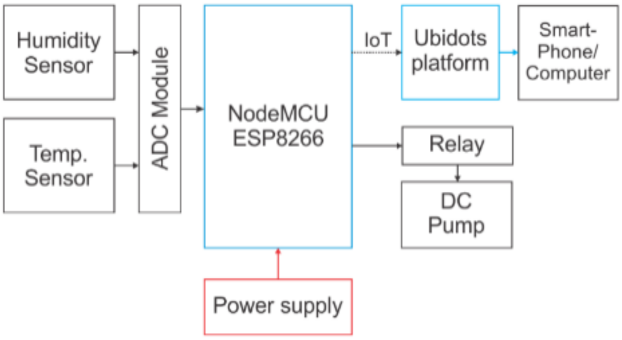
This research divides system design into two stages: the software design stage and the hardware design stage. The first stage of design, especially software realization, includes designing algorithms, flowcharts, and programs. The second stage of design includes designing and realizing a hardware system, such as block diagrams and electronic system wiring diagrams.

2.1. System design

The main component, NodeMCU, serves as a microcontroller in the design of a smart irrigation system, enabling remote use via WiFi. Figure 1(a) depicts a block diagram of the water flow process system for agricultural land irrigation, utilizing NodeMCU ESP8266, and enabling monitoring via the Ubidots application. Figure 1(b) displays the flow diagram. Figure 2 shows the wiring diagram of the proposed system. The system comprises the following components: i) NodeMCU ESP8266; ii) soil moisture sensor module; iii) soil moisture sensor probe; iv) DHT22 sensor; v) DC-DC converter module; vi) DC jack for power input; vii) DC relay; and viii) DC motor pump. First, the soil moisture sensor will automatically read the soil moisture value. The microcontroller will process this value and subsequently activate or deactivate the pump. The microcontroller activates the pump when the soil moisture value falls below 20%, and deactivates it when the soil moisture value exceeds 20%. The DHT-22 sensor then measures both hot and cold temperatures around the agricultural area. When the weather is warm, the DHT 22 sensor sends data to the NodeMCU and also sends it to Ubidots, allowing users to see the room temperature percentage via the Ubidots application. The voltage used throughout the system is 12 volts.

2.2. Designing IoT

The software design process that involves creating program code begins with initializing the component ports and program libraries of the components used so that they function properly. We create program code using the Arduino integrated development environment (IDE) software and then compile it into the NodeMCU ESP8266. The microcontroller serves as a device control system, sending data to the ubidots application.



(a)

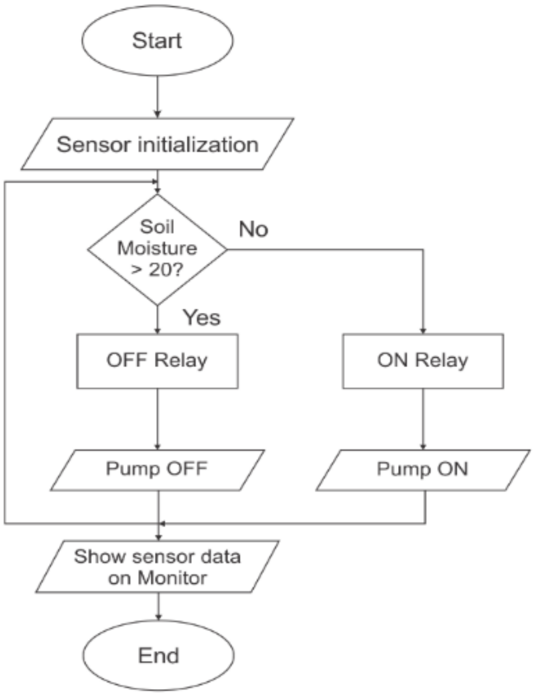


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Figure 1. System design: (a) block diagram and (b) flowchart

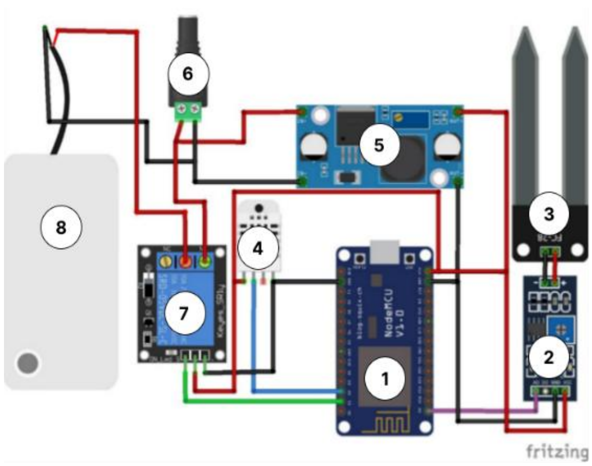


Figure 2. Wiring diagram of the sytem prototype

2.3. Ubidots application

Ubidots is a cloud service that provides intuitive and user-friendly services. User interfaces allow users to interact with a variety of devices, from mobile phones and computers to embedded systems such as microcontrollers. Ubidots serves as a platform that connects various devices to a cloud database, storing variables for easy and quick viewing. To use the Ubidots application, users must first register. The Ubidots application requires registration to facilitate the use of its features.

The software design process that involves creating program code begins with initializing the component ports and program libraries of the components used so that they function properly. We create program code using the Arduino IDE software and then compile it into the NodeMCU ESP8266. The microcontroller serves as a device control system, sending data to the ubidots application. The program code used to connect IoT devices to the Ubidots application is shown in Table 1 `#define TOKEN "BBFF-b2mYABR1CJ1adgARoCDKl3gQUz1obe"` is a token code which is obtained in the application on Ubidots. Meanwhile the program code used to read the sensors used in this application is shown in Table 2.

Table 1. Code programs connecting to Ubidots

```
client.setDebug(true);
client.wifiConnection(WIFINAME, WIFIPASS);
client.begin(callback);
#define TOKEN "BBFF-b2mYABR1CJ1adgARoCDKl3gQUz1obe"
```

Table 2. Code programs of sensors

```
nilai_analog=analogRead(soil_pin);
persentase=(100-((nilai_analog/1023.00) * 100));
float tempC=dht_sensor.readTemperature();
```

3. RESULTS AND DISCUSSION

The equipment used in this test is shown in Figure 3, which consists of: i) the soil as a medium; ii) the main controller and sensor unit; iii) a DC power supply; iv) a water and pumping system; and v) a soil moisture tester. First, we test the temperature sensors in an agricultural area to determine if the temperature is stable or uneven. The goal is to determine the temperature around the agricultural area. The second test is the soil moisture test, which determines whether the soil is dry or wet. The objective is to have the DC pump flow water if the soil is dry, and to stop watering if the soil is stable. We will calibrate the soil moisture with a Fluke thermal measuring instrument and then check the accuracy of the DHT 22 sensor and soil moisture sensor. Once we've inspected every tool, we'll neatly arrange the designed ones in a box. The final test is to test the entire system by connecting a 220V power source to the available tools. Once everything is in place, the next step involves connecting the NodeMCU to WiFi, enabling remote control via a smartphone.

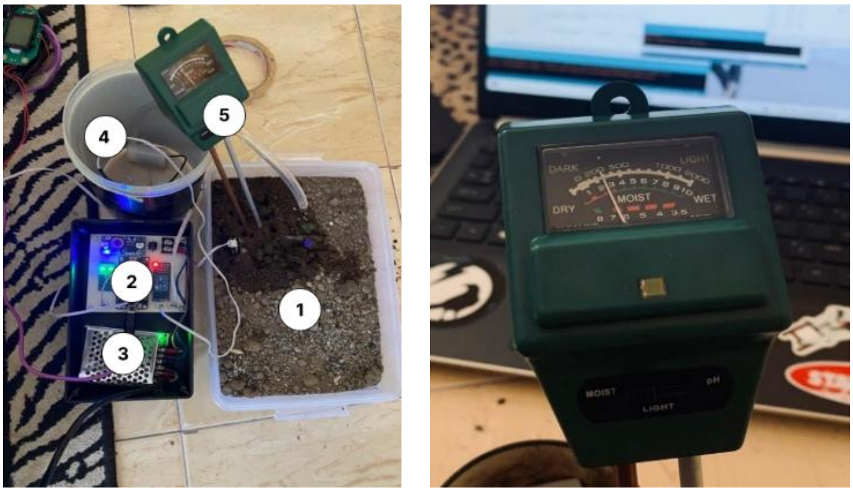


Figure 3. System testing and calibration unit

3.1. Soil to pump sensor automation testing

The essence of the automation achieved in this test is that when the unit is connected to an electrical source, the sensor activates, followed by the 5V DC pump if the soil becomes too dry. Results of the automation tests for sensors and soil pumps. Table 3 displays the data from the test results. The testing of the soil sensor system on pumps using the Internet of Things went as planned. The tool is operated by pressing the button on the Ubidots Platform provided. If the sensor value is between 0 and 20%, the pump will activate automatically. If the sensor value is greater than 20%, the pump will turn off automatically.

Table 3. Automatic test of soil sensor to pump

Automated testing of tools	Soil moisture sensor value (%)	Pump condition
1	0	*On*
2	25	*Off*
3	18	*On*
4	17	*On*
5	19	*On*
6	44	*Off*
7	45	*Off*
8	34	*Off*
9	50	*Off*
10	10	On

3.2. System testing tools to Ubidots

Figure 4 depicts the NodeMCU sending data to the ubidot when connected to a power supply. The device system will then communicate with the ubidot via a hotspot to monitor the sensor and condition. When the tool is in operation, the signal strength can have an impact on the delivery of detected data. It is heavily reliant on the internet network's stability.

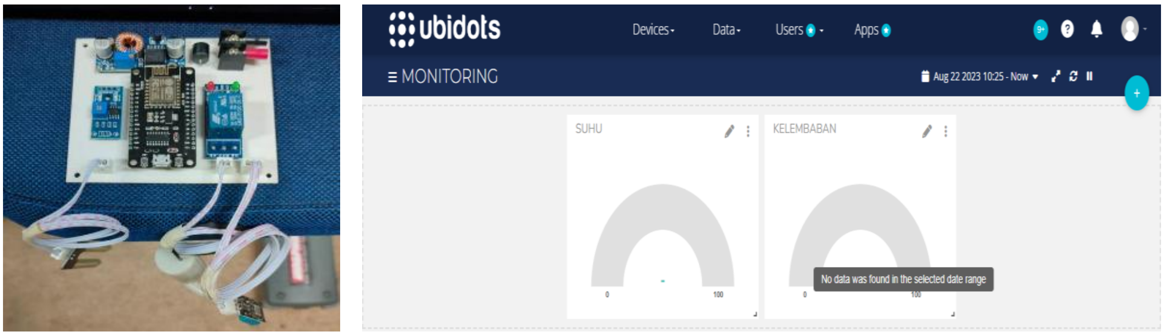
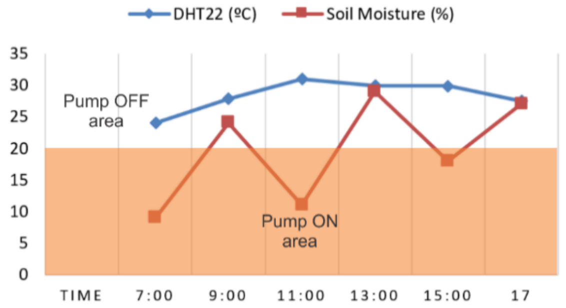


Figure 4. Tool system testing to Ubidot

3.3. Overall system testing

Figure 5(a) shows that in the 6× temperature test, the results were considered perfectly normal, namely at the highest temperature in the range of 30°C at 13:00 and at the lowest temperature at 07:00, it was 24°C. When the soil moisture sensor shows a value of less than 20%, the pump will irrigate dry land due to a lack of moisture. We obtained the lowest water content at number 9 on the first day of data collection, and the highest at number 29. As we know, temperature has a significant impact on soil quality. If the temperature is too high, the soil will be extremely dry. Conversely, if the temperature is low, the soil will become slightly damp. The first experiment identified the soil as dry, as it failed to detect any previous soil condition. The water did not flow, and subsequent experiments were based on the first. Figure 5(b) shows that in this experiment, the temperature can be considered lower than on day 1, because on day 2, the lowest temperature was 22 °C and the highest temperature was around 31 °C. Ultimately, the successful execution of the experiment hinges on the soil sensor's activity during this period. On the second day of the experiment, we recorded the driest point at 07.00 and the wettest at 09.00, both at a level of 29%.



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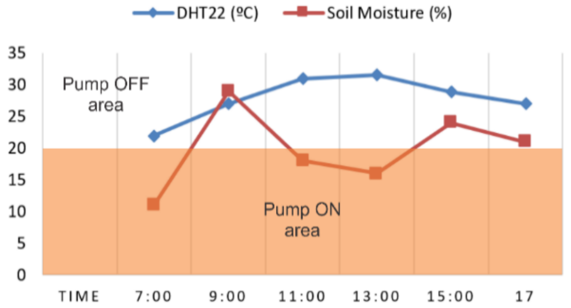

(b)

Figure 5. Overall system testing (a) first day assesment and (b) second day assesment

4. CONCLUSION

This study effectively created an Internet of Things (IoT) enabled automatic irrigation system device using the UBIDOTS platform. The device allows for remote monitoring and control of agricultural field conditions. The test results indicate that the device performs effectively, demonstrating a high level of success. The soil moisture threshold is utilized to ascertain the activation and deactivation of irrigation systems. For this study, we established a threshold of 20%. This means that the pump is triggered when the soil moisture drops below 20% and turns off when the humidity surpasses 20%. We regulate soil moisture levels to ensure consistent and optimal growth and development of plants. The pump operates for an average duration of 0-5 seconds for irrigation under simulated conditions. The monitoring system provides real-time information on the current levels of soil temperature and moisture. The response time of temperature sensors in the distribution system ranges from 1 to 3 seconds, while for soil moisture sensors it ranges from 0 to 4 seconds.

ACKNOWLEDGEMENTS

The Embedded Systems and Power Electronics Research Group (ESPERG), a research institute at Ahmad Dahlan University, assisted with the research that led to this paper.

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