



Design and Build an IoT System for Monitoring and Automation of Irrigation in Agriculture

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Abstract

This research discusses the Design and Development of an IoT System for Monitoring and Automation of Irrigation in Agriculture to increase water use efficiency and land productivity. This system uses the ESP32 CAM as a microcontroller, YL-69 soil moisture sensor to detect moisture conditions, relay and DC pump for water flow control, and the Telegram application as a medium for monitoring and control. The test results show that the system is capable of operating in real-time to monitor soil conditions, send notifications in the form of text and photos via Telegram, and automatically activate the pump when the soil is detected to be dry and turn it off again when the soil is wet.

Keywords: *Automatic Irrigation, ESP32 CAM, Internet of Things, Telegram, YL-69.*

1. Introduction

Agriculture is a key sector in meeting human food needs and is a major pillar of the economy in many countries, including Indonesia. However, the sustainability of agricultural productivity is often accompanied by challenges. One of these is the inefficient management of irrigation. With the advancement of technology, especially in the era of the Internet of Things (IoT), innovative solutions are now available that can enhance the efficiency and effectiveness of irrigation management. Therefore, the development of IoT systems to monitor and automate irrigation is a strategic step towards creating smart agriculture that adapts to the challenges of the times.

One of the main reasons is the efficiency and reliability of this technology. Traditional irrigation control systems are often based on manual methods that are inaccurate and time-consuming. At the same time, there is an increasingly urgent need for timely irrigation tailored to soil conditions to support optimal harvest yields. IoT technology allows for the integration of sensor devices for real-time monitoring of soil moisture, weather, and plant water needs. In addition, IoT-based automation provides remote control capabilities, enabling farmers to optimize water resource usage and improve agricultural productivity more efficiently.

Factors affecting paddy irrigation include flow rate and drainage. As the water overflow decreases, the amount of water flowing into the fields also decreases. This will have a negative impact on crop productivity and will pose adverse effects for farmers. One of the causes of reduced water flow is sedimentation in irrigation channels [1].

This research discusses several technological innovations in irrigation that can be used to improve water use efficiency in agriculture. First, drip irrigation systems have proven to be an effective method in reducing water leakage and minimizing unnecessary water waste. This system delivers water directly to the plant roots in the right amount, thereby reducing water loss due to evaporation. Additionally, the use of soil moisture sensors and weather monitoring technology can also enhance water use efficiency in agriculture. Soil moisture sensors assist farmers in determining the amount of water needed by plants at specific times. By monitoring the weather, farmers can schedule irrigation based on weather forecasts, avoiding unnecessary irrigation during rain or humid weather conditions [2].

2. Theoretical Fondation

2.1. Design and Build

This describes many processes to transform system outputs into programming languages, either as design or system design. The goal is to provide a detailed explanation of how to implement components. Understanding system development or evolution is an activity that creates new systems, replaces, or upgrades them, either partially or fully, with existing systems. Design refers to the design of systems and devices for the system and building systems[3]. Architecture is also an activity to translate the results of analysis into software package forms and then create the system or improve an existing system [4].

Design or system development is a series of procedures to translate the analysis results of a system into programming languages to describe in detail how the system components are implemented. Meanwhile, the definition of system construction or development is the activity of creating a new system or improving an existing system, either as a whole or

just as a system design. If the system is computer-based, the design may include specifications of the types of equipment to be used. From the explanation above, it can be concluded that system design and development is an activity of translating analysis results into a software package by determining the processes and data needed to create a new system or improve an existing system.

2.2. Monitoring

Monitoring is an activity to ensure that all organizational and management goals are achieved. On another occasion, monitoring is also defined as a step to assess whether the activities carried out are in accordance with the plan, identify arising problems so that they can be addressed immediately, assess whether the work patterns and management used are appropriate to achieve the goals, understand the relationship between activities and objectives to obtain measures of progress, and is a very important process within the organization that can determine whether an organizational goal is achieved or not. The purpose of conducting monitoring is to ensure that the main tasks of the organization can proceed according to the predetermined plan[5].

2.3. Irrigation

Irrigation is the supply of water and management activities that use surface water and groundwater to combat agricultural benefits. Agricultural irrigation agreements are not just about providing water. It can also reduce the abundance of rainwater in areas with excess water to prevent recurring water from damaging the soil. Irrigation or watering is the effort to provide water for agricultural needs that is applied correctly and appropriately to agricultural areas that require it, after which clean water is used and regularly discharged into drainage channels. Some sources of irrigation are surface water created by capturing rainfall and snow. Naturally, this water flows through rivers and carries it to the sea[6].

2.4. Internet of Things

The Internet of Things (IoT) is a technology that has been discussed recently. This technology allows the devices you use to connect to the internet later, enabling you to control your mobile phone or voice commands remotely. Like homes, many articles are connected to the Internet of Things, such as refrigerators, lights, TVs, front doors, and other objects. These can be controlled with a smartphone. The IoT works with relays and nodemcu as code storage created with Arduino IDE software [7].

2.5. ESP32 CAM

The ESP32-CAM is a development device based on the ESP32 board that can be paired with a camera and is equipped with WiFi and Bluetooth, as well as an external antenna. In the process of uploading source code, the ESP32-CAM does not have a USB to serial interface, thus requiring an external interface[8].

2.6. YL-69 Sensor

The soil moisture sensor used in the design of this tool is the YL-69 sensor. It is a sensor capable of reading the amount of moisture content in the surrounding soil. This sensor uses two conductive probes to send current through the soil, then measures the resistance value to determine the moisture level. The output circuit of the YL-69 sensor is connected to Port A0 on the microcontroller. This type of sensor can operate from a voltage of 3.3V to 5V. According to , the YL-69 soil moisture sensor is capable of detecting moisture within the soil. This sensor consists of two electrodes (probes) that will read the moisture content in the surrounding area, allowing current to pass from one electrode to the other. The current is passed through the electrodes in the soil, so the measurement of soil resistance determines its moisture content. If the soil has a higher moisture content, the sensor output will decrease, making it easier for current to passing through the censorship process.

2.7. DC Pump

A pump is a device that moves liquid from one location to another by increasing the pressure of the liquid. The increase in liquid pressure is used to overcome drainage obstacles. Damage in rivers can occur in the form of pressure differences, high levels, or frictional resistance. Essentially, a pump converts the mechanical energy of the machine into liquid energy.

2.8. Telegram

Telegram is a cloud-based instant messaging service that has become a means of communication for all circles; the ease and speed in message delivery are significant advantages that greatly assist the wider community, so Telegram has a large number of users. Besides being used for message delivery, we can also develop systems using the bot feature (Telegram accounts operated by a program)[9].

2.9. Relay

A relay is an electronic component in the form of an electronic switch that is activated by electric current. The relay has a low center-wound coil wrapped around a core, with an iron armature that will be attracted to the core when current flows through the coil. A relay is an electrically operated switch and is an electromechanical component consisting of 2 main parts, namely the electromagnet and the mechanical part[10].

3. Design and Analysis

3.1. Research Methodology

The method used in this research is the design method (prototyping). This method includes several main stages, namely:

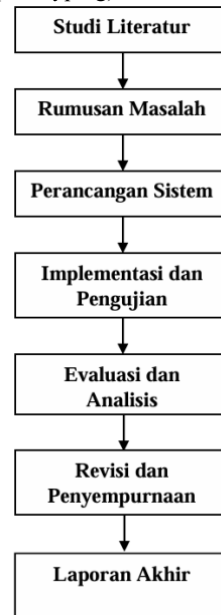


Fig. 1: Research Methodology

3.2. Control System Flowchart

The design of this tool begins with the creation of a flowchart to facilitate the planning and development of the program on the microcontroller. The creation of a flowchart is useful for simplifying the understanding of the working process of the tool. The program flowchart from this research includes the control system of the tool's operation, which can be seen below.

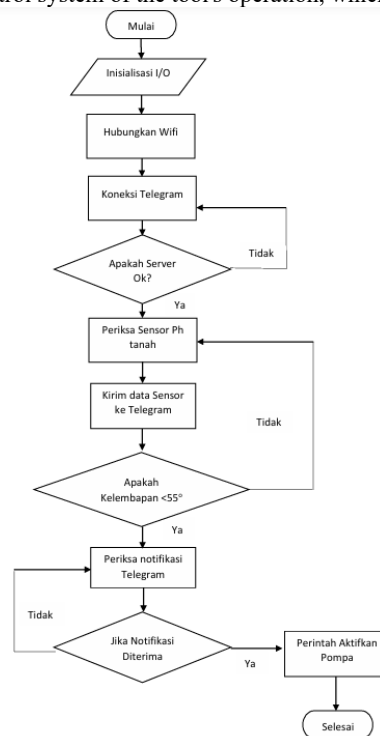


Fig. 2: Control System Flowchart

The following is an explanation of the Irrigation Control System Flowchart for agricultural land as follows:

1. Start
2. Initialize Input and Output
3. Connect the device to the internet such as Wi-Fi.
4. Connect Telegram.
5. Is the server okay? If yes, proceed to the next process. If not, return to the initial connection.
6. Check the sensor; if the sensor is active, then the device can operate.
7. The microcontroller sends data received from the sensor to Telegram.
8. If the sensor data is received with a value $<55^{\circ}\text{C}$, then check the Telegram application. If not, recheck the sensor.

4.2. Hardware Testing

After all the programs are typed, design the hardware as shown below

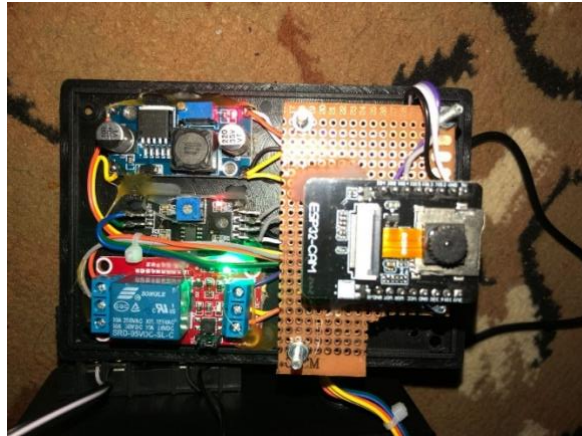


Fig. 6: ESP32 CAM Circuit with Relay and Soil Sensor

Next, the test for the device's activity, based on the indicators in the active/on circuit:

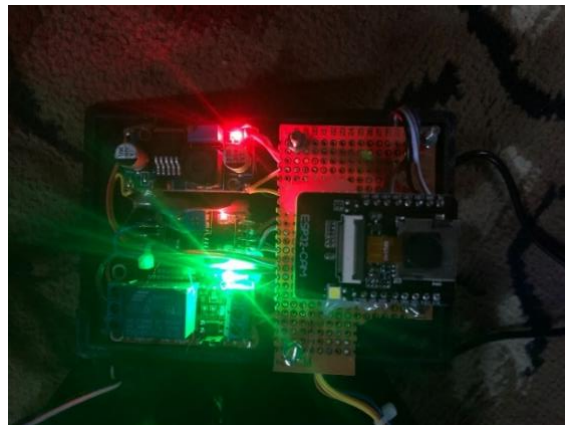


Fig. 7: Active Tool Position

4.3. Telegram Testing

In this Telegram test, we create a new Bot named `Pertanian_irigasibot` as shown in the picture below:

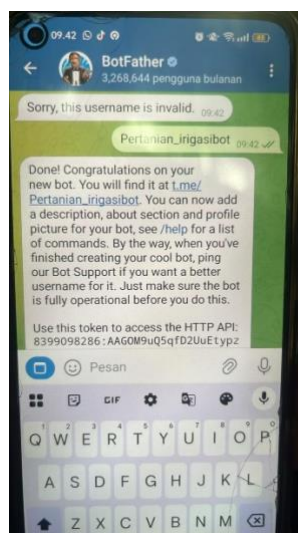


Fig. 8: Telegram Display

After the program has been fully typed, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE and then clicking upload, with the note that the Board and Port in the Arduino IDE Bar menu are already set. Next, wait a moment until the upload process is complete, then the program that has been uploaded will automatically be saved to the microcontroller.

4.4. Implementation of Overall Testing Using Irrigation Prototype With ESP32 CAM And Soil Sensor Connected With Telegram

The implementation of this testing is conducted to assess the performance of the components to be used in this thesis with the output being a Telegram notification that will monitor irrigation in agricultural land through soil pH sensor detection, sending the sensor data generated concerning dry or wet soil status to Telegram in the form of photos and notifications in real time. With both being connected to the internet, Telegram can receive data sent by the microcontroller. This experiment is carried out by placing the ESP32 at the end of the land to take photos of the irrigation, then if the soil is detected as dry, the pump will automatically activate and a notification will be sent to Telegram. The notification experiment on Telegram was conducted several times to ensure the device works successfully. After all the circuitry has been successfully designed in the "Design and Construction of an IoT System for Monitoring and Automating Irrigation in Agriculture", here is the image of the successful irrigation monitoring system testing agriculture using IoT in the images below:



Fig. 9: Overall Circuit Results



Fig. 10: Result of Telegram Notification Testing

5. Conclusion

The IoT-based irrigation system prototype has been successfully designed, implemented, and tested using components such as the ESP32-CAM, YL-69 soil moisture sensor, DC pump, and relay, with the Telegram application integrated as the main platform for monitoring and remote control. The system is capable of continuously detecting the soil's moisture level in real time, ensuring that irrigation decisions are based on accurate and up-to-date conditions of the farmland. When the soil moisture drops below a certain threshold, the prototype can activate the pump through the relay to supply water, thereby helping maintain optimal soil conditions for crops. In addition, the ESP32-CAM enhances the system by capturing actual images of the land, which, together with text-based notifications, are sent via Telegram to provide users with both visual and numerical information about the field's state. This combination of automation, sensing, and remote communication offers farmers a practical tool for efficient water management, reduces the need for manual checking, and supports more sustainable agricultural practice.

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