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PROTOTYPE OF RICE FIELD IRRIGATION SYSTEM USING ARDUINO UNO MICROCONTROLLER AND TELEGRAM

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Abstract: In agriculture, irrigation systems are vital for enhancing water management and maximising plant growth. Effective irrigation management involves distributing sufficient quantities of water evenly to condition soil fertility for plants. This study aims to design a prototype that can be monitored via the Telegram app. The research methodology employs a thinking framework approach. The system is implemented using an Arduino Uno microcontroller and supporting devices, including an ESP8266 Wi-Fi module, an ultrasonic sensor, a soil moisture sensor, a stepper motor and a servo motor. Telegram serves as the monitoring tool, sending notifications connected to the Arduino via a Wi-Fi network. Test results showed that the system operates effectively: the HC-SR04 ultrasonic sensor functions as a water level reader, and the stepper motor opens and closes the water gate. Soil moisture monitoring uses a soil moisture sensor to measure the water content in the soil. If the sensor detects dry soil conditions or a moisture level below 60%, the servo motor will rotate 15° to close the water channel. Conversely, if the sensor detects wet or moist soil conditions, the servo motor will rotate 0° to close the water channel.

Keywords: arduino uno; irrigation system; soil moisture; ultrasonic sensor;

Abstrak: Sistem irigasi dalam pertanian memiliki peran penting dalam meningkatkan efesiensi penggunaan air dan mengoptimalkan pertumbuhan tanaman. Pengaturan irigasi yang baik harus mampu mendistribusikan air yang dapat mengkondisikan kesuburan tanah dalam jumlah yang cukup tinggi bagi tanaman secara merata. Pada penelitian ini bertujuan untuk merancang dalam bentuk prototipe yang dapat di monitoring melalui aplikasi telegram. Metodologi peneltian ini menggunkan metodologi kerangka kerja atu kerangka berfikir. Sistem dibangun dengan menggunkan mikrokontroler Arduino uno dan perangkat pendukung seperti modul *wifi* ESP8266, sensor ultrasonic, sensor *soil Moisture*, motor stepper dan motor servo. Telegram sebagai monitoring dengan cara memberikan notifikasi, yang terhubung dengan Arduino melalui jaringan wifi. Berdasarkan hasil pengujian, terlihat bahwa sistem dapat berjalan dengan baik, adanya sensor *ultrasonic* HC-SR04 sebagai pembaca ketinggian air dan motor stepper sebagai alat untuk buka tutup pintu air. Monitoring kelembaban tanah menggunakan sensor *soil moisture* untuk mengukur kadar air yang ada di dalam tanah dan jika sensor soil moisture membaca kondisi tanah dalam keadaan kering atau kurang dari angka 60% persen maka motor servo akan berputar 15° untuk menutup jalur air, dan jika sensor soil moisture membaca kondisi tanah dalam keadan basah atau lembab maka motor servo akan berputar 0° untuk menutup jalur air.

Kata kunci: arduino uno; sistem irigasi; *soil moisture;* sensor ultrasonik.

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INTRODUCTION

Irrigation involves delivering water to fields on a regular basis by constructing structures or channels, as well as removing excess water after optimal use [1]. Farmers in Indonesia generally use surface irrigation, which is heavily influenced by gravity. This means that lower land is irrigated first, followed by higher land[2].

In modern agriculture, wise use of water resources is essential to ensure sustainable food production. Along with these advancements, various improvements to irrigation methods are now being implemented to increase water distribution efficiency, reduce water surplus, and increase crop production[3]. Plants need water to grow, develop, and produce well [4]. Rice cultivation requires adequate water supply [5].

The development of automatic water control systems for irrigation canals involves the use of microcontrollers, with Arduino being a prominent choice due to its ability to store and process sensor data [6]. Unmonitored water irrigation will have a significant impact, causing crop failure if crops are water-stressed or overwatered [7].

Previous research has led to the development of an automated irrigation system. This system uses an Arduino Uno, water level sensors, and servo motors. Photos of the land are sent to Telegram when the rice fields are experiencing extreme water conditions (too dry or flooded) [8]. Another study focuses on an Internet of Things (IoT)-based automatic soil moisture monitoring and watering system for potted plants. Soil moisture sensors are connected to an Arduino, and data is sent to Telegram. The pump is automatically activated when the moisture level falls below a certain threshold [9].

Although many studies have been conducted on microcontroller-based automatic irrigation systems, sensor reliability has not been adequately evaluated in the field. Soil moisture and water level sensors used in Arduino-based prototypes are often not tested for extended periods of time in extreme field conditions, such as mud, rain, and high heat. Therefore, the long-term durability and accuracy of the sensors is unknown [10].

Based on the background information and identified gaps, the objective of this research is to design and build an Arduino Uno-based prototype irrigation system for rice fields. This system will automatically control pumps and/or irrigation gates based on soil moisture and rice field water level sensors.

METHOD

This research method provides a framework for taking action or thinking, and for developing ideas that are focused and related to goals and objectives. The method used in this research is shown in Figure 1.

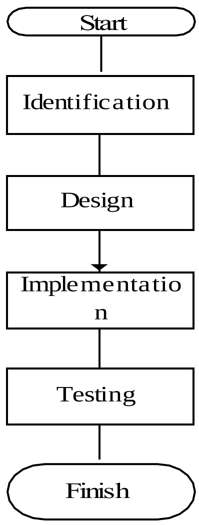

Figure 1. Research framework

Identification

At this early stage, the requirements needed to design a system are identified. At this early stage, the first step is to analyze the reasons behind this research. This identification stage consists of two parts: identifying requirements and identifying working methods.

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Design

The research design involved developing a work system analysis, which was then converted into block diagrams to help researchers understand the flow and functions of the planned design.

Implementation

The implementation stage is the stage where all designs, including hardware designs, are carried out. The hardware implementation stages include connecting modules and implementing telegrams.

Function Testing

At this stage, various tests that have been implemented in the previous stages are carried out.

Result

The final result of this research is a prototype irrigation system for rice fields using an Arduino Uno microcontroller, monitoring, and Telegram.

RESULT AND DISCUSSION

At this stage, we will discuss the needs identification analysis and system work analysis in hardware to support the implementation of tools and testing of tool series in rice field irrigation systems using Arduino Uno microcontrollers and Telegram in the system that has been created.

Identification

Implementing an Automatic Irrigation System Using a Microcontroller. The Arduino Uno can be summarized by several system requirements. Based on previous problems, several requirements are needed. First, identify the necessary hardware and working methods. The following figure illustrates this analysis.

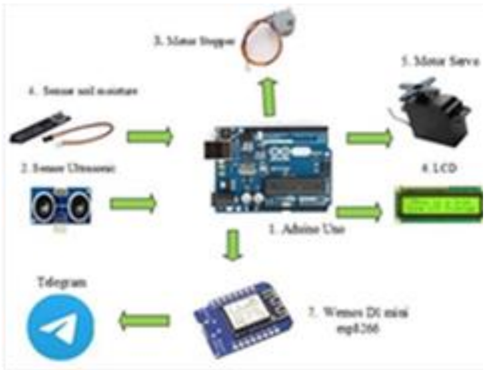

Figure 2. How it works

Design

At this stage, several designs related to the research have been carried out. The following is an overview of the stages of the system design process in this study.

Hardware Design

At this stage, the hardware design is carried out in accordance with the research that has been conducted. This research is divided into several hardware system designs, which are described in the following block diagram:

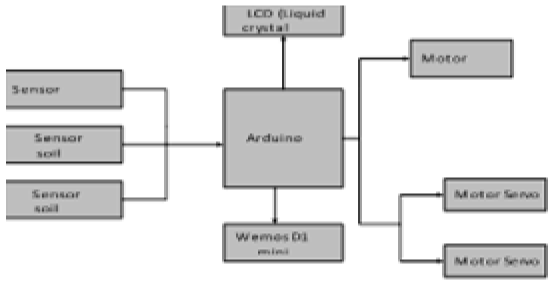

Figure 3. Block Diagram

Arduino Schematic Design Series with Ultrasonic Sensor The sensor used is an HC-SR04 ultrasonic sensor, which is used to measure the distance of an object. This sensor works based on the principle of sound wave reflection, so it can detect the presence of objects at a certain frequency. This sensor is called an ultrasonic sensor because it uses ultrasonic waves (ultrasonic sound).

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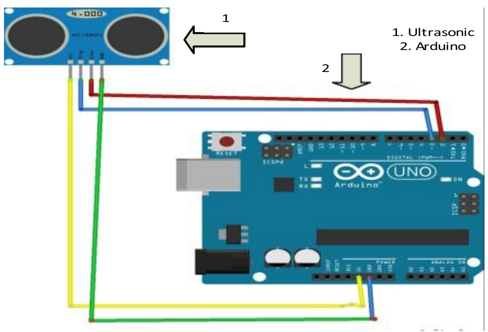

Figure 4. Ultrasonic Sensor Circuit

Soil Moisture Sensor Array this sensor is used to detect soil moisture. It works using the principle of capacitance (a measure of the amount of electrical charge stored).

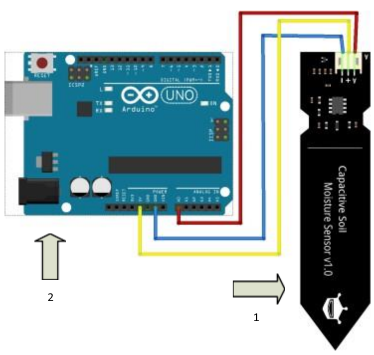

Figure 5. Soil Moisture Sensor Circuit

Stepper motors are a type of motor that is widely used as actuators. These motors are most often used as drive heads on disk drives and are also frequently used in robotics. Stepper motors can be controlled via microcontrollers to regulate their rotation.

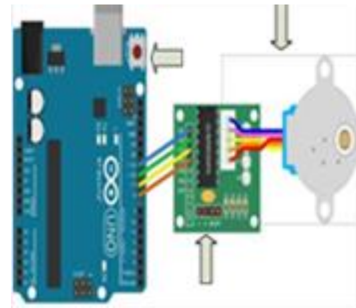

Figure 6. Stepper Motor Circuit

The Servo Motor Module Series functions as an opener and closer for waterways. Servo motors are motors with high torque and controlled angles of movement. Similar to stepper motors, servo motors have limited movement.

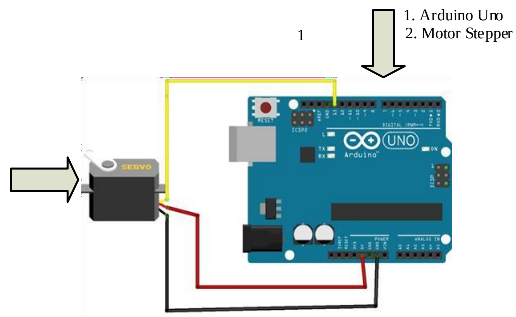

Figure 7. Servo Motor Circuit

The Wemos D1 mini series is a module used to connect Arduino to the internet. To use it, you need the ESP8266Wifi library and Serial Software.

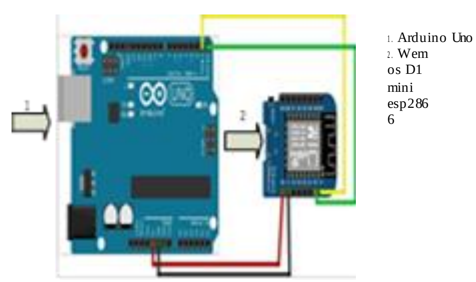

Figure 8. Wemos D1 Circuit

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Network Topology Design

The network topology design shows that the ESP8266 WiFi module connected to the switch, as well as the prototype circuit for the rice field irrigation system using Arduino and Telegram, have been programmed according to the programming instructions that have been created.

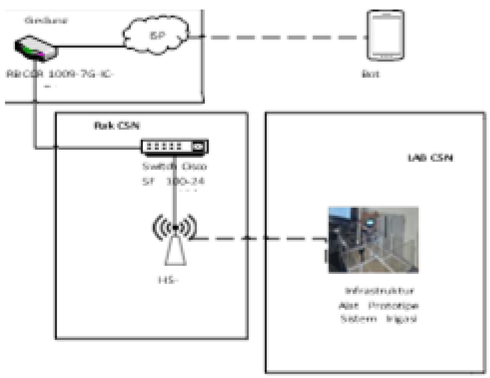

Figure 9. Network Topology

Figure 9 shows the network design that will be created in the device series. From the internet source, it connects to the Mikrotik RB CCR 1009-7G-1C-15+ router with an IP address of 10.10.0.1/21. The RB CCR 1009-7G-IC-15+ router connects to a switch on the CSN (Computer System and Network) Laboratory server rack. The switch connects to the prototype irrigation system device infrastructure, which has a DHCP IP address from the RB CCR 1009-7G-IC-15+ router. The prototype irrigation system infrastructure then sends notifications of water level and soil moisture values to the Telegram bot.

Implementation

Implementation refers to the assembly or installation of all components prior to their actual implementation in the system. The following are the implementation stages that will be carried out using the following system workflow:

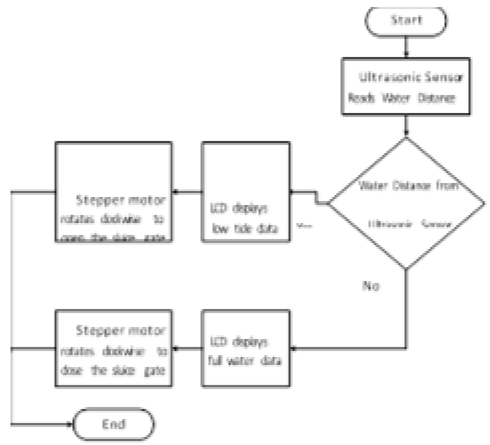

Figure 10. Water Gate System Workflow

Function and Tool Testing

This testing is conducted to ensure that the device meets its intended purpose. Below are the steps for testing the rice field irrigation system prototype device circuit using an Arduino Uno microcontroller and Telegram.

Testing the function of ultrasonic sensors At this stage, we test the function of the ultrasonic sensor. This test is conducted by moving objects closer to and further away from the sensor.

Figure 11. Ultrasonic sensor testing

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Table 1. Ultrasonic Sensor Testing

Water Level	Water Conditions	Description
10 cm	Low Tide	Sluice Gate Open
7 cm	Low Tide	Sluice Gate Open
4 cm	High Tide	Sluice Gate Closed

Based on the test results, the ultrasonic sensor for reading the water level condition works well according to the input provided. if the water distance is greater than or equal to 6 cm from the ultrasonic sensor, then the water is in a dry state and the water door will open, and if the water distance is less than 6 cm from the ultrasonic sensor, then the water is in a full state and the water door will close.

Stepper Motor Function Testing

This stepper motor test is intended to ensure the performance of the stepper motor for opening and closing the floodgate, which receives input from an ultrasonic sensor, whether it is functioning or not.

Table 2. Stepper Motor Testing

Distance From Ultrasonic Sensor	**Stepper Motor Condition**	**Description**
>= 6cm	Stepper motor Rotates to Open the Floodgate	Water Gate Open
<6 cm	Stepper motor Rotates to Close the Floodgate	Water Gate Closed

Based on the test results, it can be seen that the stepper motor moves according to the distance input provided by the ultrasonic sensor. If the distance is greater than or equal to 6 cm, the stepper motor will rotate clockwise to open the water gate, and if the distance is less than 6 cm, the stepper motor will rotate counterclockwise to close the water gate.

Soil Moisture Sensor Testing

Sensor function testing is carried out by calibrating the sensor. The calibration process consists of two stages. First, analog data values and percentages are measured when the sensor is dry. The second stage involves the same measurements when the sensor is wet.

The calibration test for soil moisture readings is carried out by first reading the analog values to determine the percentage values of the sensor in a dry state and the sensor in a wet state. From the dry and wet sensor conditions, dry and wet analog values are obtained, which are then used as a line equation function for percentage values from 0% to 100%. The analog value data or ADC (analog to digital converter) of the soil moisture sensor has a value range of 1024 bits, starting from 0-1023 bits.[11].

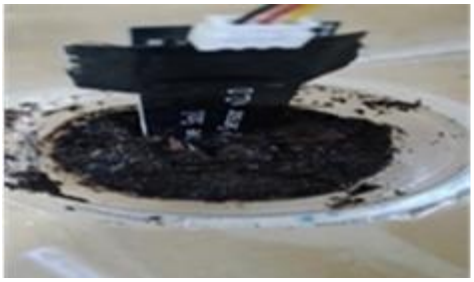

Figure 12. Soil Moisture Testing

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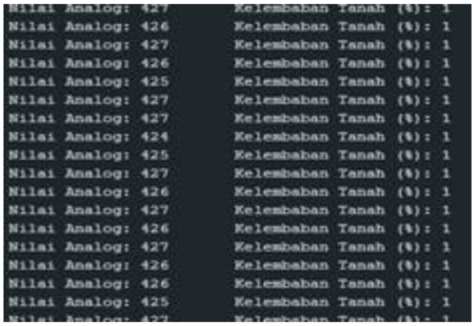

Figure 13. Analog value readings and percentage of sensors on dry soil

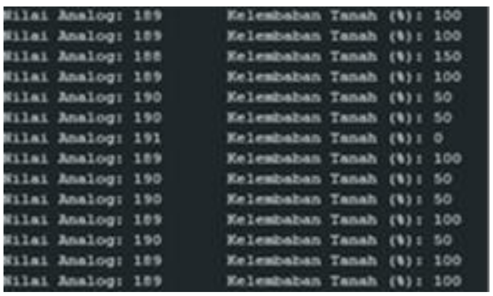

Figure 14. Analog Value Reading Wet Soil Sensor Percentage

Servo Motor Testing

In testing, this servo motor functions as an opener and closer for the water channel to the rice fields or land. The servo motor is placed near the water channel that leads to the land or rice field area. For testing, see Figure 15.

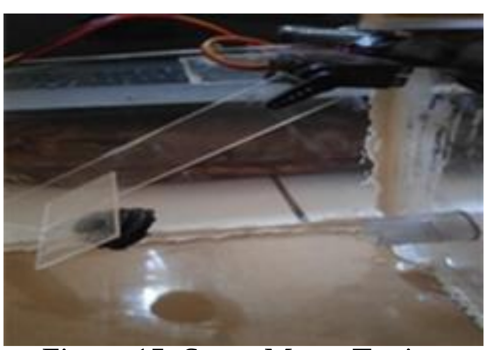

Figure 15. Servo Motor Testing

Table 3. Servo Motor Testing

Soil Moisture	Servo Motor Rotation	Description
83 %	0°	Servo Motor mov e to close The water Way
40 %	0°	Servo Motor mov e to open The water Way

Based on the results of testing the Stepper Motor, the stepper motor rotates based on the conditions provided by the soil moisture sensor. If the soil moisture sensor reads that the soil is dry or less than 60%, the servo motor will rotate 15° to close the water channel. If the soil moisture sensor reads that the soil is wet or moist, the servo motor will rotate 0° to close the water channel.

Telegram Testing

This step is carried out to test the functionality of Telegram. This test is conducted as a notification. The system will send a Telegram message containing information on water level and soil moisture.

Figure 16. Telegram Testing

CONCLUSION

A design has been made for a prototype irrigation system that can automatically distribute irrigation water using an HC-SR04 ultrasonic sensor to read water levels and a stepper motor to open and close the water gate. Soil moisture monitoring uses a soil moisture sensor to measure the water content in the soil and a servo motor to open and close the water flow to the rice fields.

Water level and soil moisture data is sent via notification to Telegram through a Wemos esp8266 module connected to Arduino Uno.

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