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Design of Irrigation System Based on Arduino Uno Using Soil Moisture Sensor

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Abstract

Water needs are very necessary for the agricultural sector in caring for plants properly. However, in the management process, farmers have a watering time that is not tools used to help farmers' performance. With automatic irrigation system technology, farmers can take advantage of solutions to make it easier to care for plants. The automatic irrigation system utilizes and Arduino Uno based soil moisture sensor as a soil moisture detector. Soil moisture sensors are tested for soil moisture in dry, slightly moist, wet and mossy soil conditions. The test results show that the sensor can read the condition of soil moisture < 60%, then the waterpump does not move and does not water automatically, otherwise if the soil moisture > 60% will work automatically with the average soil moisture produced after watering by 61% and obtain a neutral pH.

Keywords*—Irigation system, Soil moisture, Arduino UNO*

1. INTRODUCTION

Indonesia has a tropical climate, the lack of rain in certain areas is one of the contributing factors. The need for water is so important for the agricultural sector, considering the available water needs, an irrigation system is needed to meet these needs. Irrigation is an effort to bring water by making buildings or channels to the rice fields regularly and using water as well as possible [1]. Water is said to be available for plants if the water in the pores of the soil can be taken by the roots of the plant [1]. One of the problems experienced by farmers is the provision of irrigation and watering which requires labor and quite high electricity costs [2], [3]. Therefore, with a good irrigation system, the fulfillment of water needs for food crops, livestock and fisheries can be met [4].

The rapid advancement of technology has made many people innovate to create new things, one of which is creating a smart garden system. Almost all human activities use the latest technology, starting from the industrial world, households and even in agriculture [5]. The need to care for plants certainly requires time and the right amount of water according to the plants. The author applies it to an automatic irrigation system that aims to facilitate and maximize farmers and garden owners in caring for the land. By utilizing Arduino Uno microcontroller technology and utilizing a soil moisture sensor as a soil moisture detector sensor. The soil moisture sensor can provide optimal soil moisture to improve the quality of plant growth [6], [7].

In the field of agriculture, microcontroller technology is used to carry out the process of watering regularly and on schedule for plants [5]. Agriculture requires large amounts of water, but inefficient use of water in agriculture if there is excessive watering which causes leaching of nutrients and fertilizers in the root system and ultimately reduces crop yields [8]. In previous studies, an automatic irrigation system was developed using an ultrasonic sensor to read the distance of water, if the distance of water is normal, the servo opens 180 ° [1]. The soil moisture sensor is directly related to the amount of irrigation in agriculture and affects crop yields [8]. Therefore, the soil moisture sensor is an important tool for measuring soil water content [8]. Basically, the soil moisture sensor refers to the water content in the soil, and plant growth is closely related to the water content in the soil [8]. The water content in the soil has different levels of acidity (pH), so it can affect the quality of the soil in farming [9], [10]. In this study, there is a water pump that will actively provide water, if the sensor detects soil moisture of less than 60% according to soil conditions.

2. LITERATURE STUDY

Automatic irrigation system is a technology development that can be useful to simplify and maintain soil moisture so that it can be maintained in real time by implementing components and software to support it.

2.1 Irrigation system

Irrigation system as an irrigation requirement on agricultural and plantation land to maintain the quality of plant growth. In managing the irrigation system requires an active role from related parties such as agriculture and government, to manage and increase production capacity and improve services in the irrigation process [11]. Agriculture and water are interrelated, where water determines crop production and agriculture affects the hydrological cycle in groundwater absorption [6].

2.2 Arduino Uno

Arduino Uno is one of the microcontrollers that functions as a control system, to control a system automatically [1], [10], [12], [13]. By using Arduino Uno technology, it can be easier to create an automatic monitoring system [14]. To be able to control the microcontroller using Arduino IDE software [15].

The research conducted includes applied research, with experimental research methods (Rindi Wulandari, 2022). The mini weather station design process consists of design & ideas, product analysis, PCB design, hardware and software. Design and ideas include the initial planning of the project to be created. Product analysis is to determine the amount of material/components used. PCB design design to create a PCB circuit path. Hardware design includes what hardware is used in making this mini weather station, while software design includes creating a program for the Arduino Mega 2560 as a control unit. Figure 1 shows the flowchart of the system to be designed.

2.3 Soil Moisture Sensors

The soil moisture sensor is a sensor that defines the water content in soil or agricultural land by knowing the value of the soil on wet and dry plants [16], [17]. The application of a soil moisture sensor can be used to monitor the value of soil moisture in plants and plants on agricultural land [6]. These sensors can influence crop yields by measuring soil water content [18]

3. RESEARCH METHODS

The author carried out several stages of the process carried out in this study using the waterfall method. This method aims at the system development process, which consists of analysis, design, implementation, testing, and maintenance [16], [19].

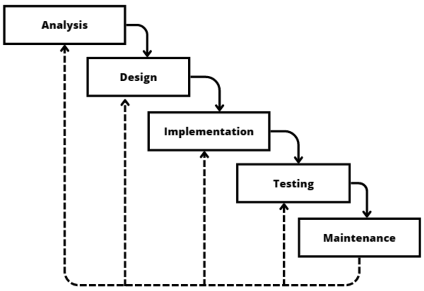

Figure 1. Waterfall research flow diagram

Here are the stages of the research process:

1. Analysis

This stage explains the analysis of literature study data from previous researchers, through several sources by observing the shortcomings of previous tools.

2. Design

In this section, the author prepares the design of an automatic irrigation system tool based on Arduino Uno using a soil moisture sensor, by utilizing the fritzing application as a circuit schematic and flowchart as a system flow diagram.

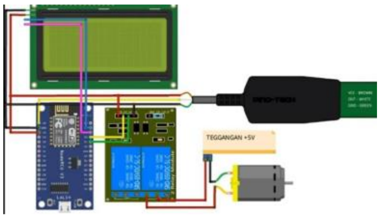

Figure 2. Schematic of automatic irrigation system using fritzing

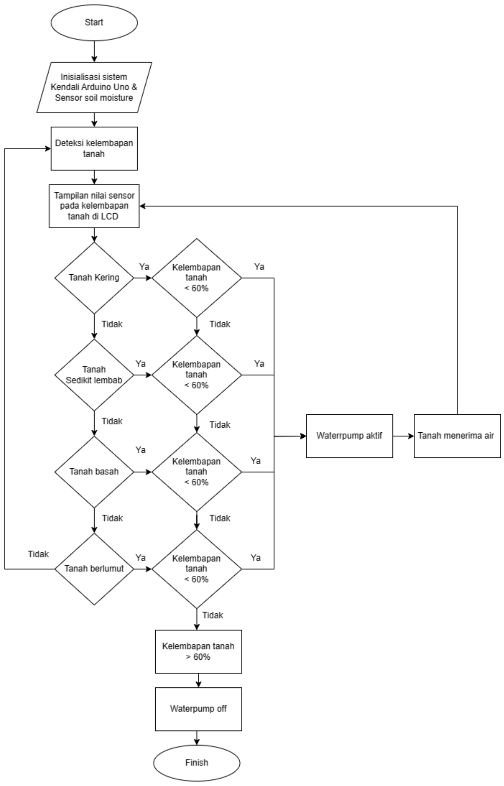

Figure 3. Flowchart of the tool's working system

In the flowchart section, it can be explained that Arduino Uno is the control center to give commands to the soil moisture sensor to identify soil moisture values that are less than 60% from different soil conditions. So that the water pump will automatically provide water to the soil if the soil moisture value is less than 60%. The water pump will automatically stop when the water content in the soil is as desired.

3. Implementation

The programming process uses Arduino IDE software as the program control center on Arduino Uno.

4. Testing

Tool testing aims to ensure that the tool works properly and analyzes the results of sensor readings on soil moisture.

4. RESULTS AND DISCUSSION

Based on the tests that have been carried out, it is obtained with several stages as follows:

3.1 Soil Moisture Sensor Testing

This stage is carried out to obtain the level of accuracy on the sensor. This test is carried out to determine the condition and results of the data obtained in the automatic irrigation system, which is seen in Figure 4. Soil moisture is carried out on dry, semi-wet and wet soil to detect the level of moisture in the soil.

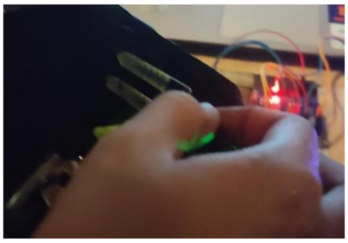

Figure 4. Soil moisture sensor testing

3.2 Relay Testing

The relay test aims to determine the voltage conditions of 0 and 5 volts to activate and stop the electric current on the pump (in figure 5). If the relay is active, the electric current provides power to the water pump and vice versa if the relay is off, the water pump process stops.

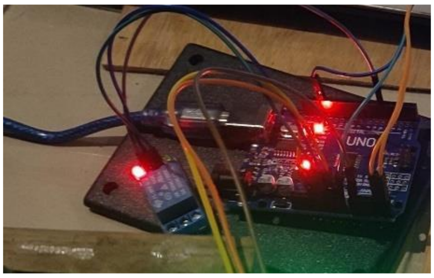

Figure 5. Relay testing

3.3 Water Pump Testing

This testing phase aims to ensure that the water supply in the form of a hose provided from the water pump can run according to the expected system.

3.1 Automatic Irrigation System Testing

This test is carried out to determine the overall system work process of the components that have been designed by measuring different soil conditions. Thus, the data obtained from the soil moisture sensor can be managed through the Arduino IDE software and the data is displayed on the LCD (figure 6).

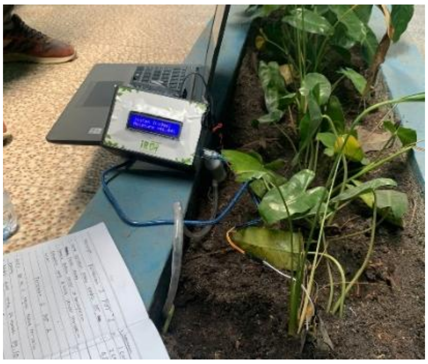

Fig. 6 Overall component testing

From the system testing stage, the data results from soil moisture sensor readings with different distances and soil moisture are obtained in the following table. Table 1 explains the indicators of pH value and soil moisture conditions. The level of soil fertility can be observed at the acidity level with different parameters, chemically, namely acidic, neutral, and alkaline pH [20].

Table 1. Indicators of pH values and soil moisture

Variable	Value indicator	Information
Soil pH	0 – 6	Acid
	6 – 7,5	Neutral
	8 – 14	Base
soil moisture	0% – 59%	Dry
	60% – 70%	Normal
	75% – 140%	Wet

Table 2 shows that in experiments in wet soil conditions, the sensor identified the water content in the soil at a depth of 2 cm – 4.5 cm as having a basic soil pH.

Table 2. Results of system testing under wet soil conditions

Step	Sensor depth distance (cm)	Initial humidity <60%	*Waterpump*	Final humidity >60%	Watering time (*minute*)	Soil pH information
1	2 cm	82%	Inactive	82%	-	Alkaline
2	4,5 cm	84,75%	Inactive	84,75%	-	Alkaline

Table 3. System test results on slightly damp soil conditions

Step	Sensor depth distance (cm)	Initial humidity <60%	*Waterpump*	Final humidity >60%	Watering time (*minute*)	Soil pH information
1	1 cm	39,10%	active	78,69%	03.00.21	Alkaline
2	2 cm	46,02%	active	74,78%	01.34.20	Neutral
3	3 cm	54,23%	active	79,33%	01.34.20	Alkaline
4	4,5 cm	58,13%	active	82,04%	01.34.20	Alkaline

Table 3 The experiment was successfully carried out by the sensor 4 times, with different levels of depth into the soil in slightly moist soil conditions. Thus, it has an average

value of soil moisture at the beginning of the sensor being inserted and read less than 60%. The longest time taken to provide water at a depth of 1 cm with a time of 3 minutes, in order to obtain the soil moisture needed by the plants.

Table 4. The sensor successfully reads in dry soil conditions with an initial humidity value obtained <60%. So that the water pump is active to provide water with a time obtained of ±3 minutes.

Table. 5 sensors show the identification results on mossy soil with neutral soil moisture and pH values. Because, basically moss plants contain water, so the sensor does not need a long time to produce the desired pH value.

Table 4. System test results on slightly damp soil conditions

Step	Sensor depth distance (cm)	Initial humidity <60%	*Waterpump*	Final humidity >60%	Watering time (*minute*)	Soil pH information
1	1 cm	46,04%	active	69,40%	03.34.66	Neutral
2	2 cm	46,04%	active	76,54%	03.34.66	Alkaline
3	3 cm	47,02%	active	78,30%	03.34.66	Alkaline
4	4,5 cm	67,16%	inactive	67,16%	-	Neutral

Table 4. System test results on slightly damp soil conditions

Step	Sensor depth distance (cm)	Initial humidity <60%	*Waterpump*	Final humidity >60%	Watering time (*minute*)	Soil pH information
1	1 cm	40,86%	active	61,02%	00.36.42	Neutral
2	2 cm	47,31%	active	61,39%	00.36.42	Neutral
3	3 cm	53,57%	active	64,32%	00.36.42	Neutral
4	4,5 cm	58,75%	active	69%	00.36.42	Neutral

5. CONCLUSIONS

Based on the research results of the Arduino-based automatic irrigation system using soil moisture sensors that have been obtained, it can be concluded that this system can facilitate work in agriculture and plantations automatically. The results of the sensor experiment data show that soil conditions determine a neutral soil pH of 6 - 7.5 with an average initial humidity value of 45% and final humidity after being given water automatically with an average of 61%. Thus, the soil moisture sensor can show the accuracy of reading soil water content conditions <60% and Arduino Uno can instruct to provide water automatically through a water pump.

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