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A Fuzzy Rule-Based Approach for Automatic Irrigation System through Controlled Soil Moisture Measurement

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ABSTRACT

Soil moisture volume is the greatest attribute of soil. Irrigated farms rely on controlling the two fundamental raw materials; water and soil. Putting excessive water enlarges the pumping costs, decreasing the water effects to the soil, and cause contamination or pollutant. The study aims to develop an irrigation water management system that controls the volume and frequency of irrigation water applied to the soil and to use low-cost sensor device that measures the soil moisture level accurately like the high price sensor in the market. The FC-28 soil moisture sensor was also validated conducting (60) sixty trials with different soil and the readings are the same for soil moisture measurement devices in the market. Based on the testing, the whole system resulted in a 100% success rate in system and functionality testing. This study proves that the automatic irrigation system controlled by soil moisture sensor is efficiently and accurately.

Key words : Arduino, Fuzzy Rule-Base, Irrigation System, Soil Moisture, Water.

1. INTRODUCTION

Irrigation is the process of applying water to the soil to make enough soil moisture that is obtainable for fine quality plant growth. In irrigation, water and soil togetherness is essential. If the two are not compatible, the enforced irrigation water will cause unhealthy results or effects on soil. Discovering the appropriate dry land for irrigation recommends a comprehensive assessment of the soil properties, the area of the land for farming and the variety of water to be utilized for irrigation.

Irrigated farm relies on controlling the two fundamental raw materials; water and soil. Water is needed to strengthen or support physically the plant and soil is the mounting ground of plant life. The intelligent utilization of soil and water involves a necessary knowledge for these resources [1].

Soil moisture volume is the greatest attribute of soil. The plant needed the soil because soil serves as the storage area of water. Soil moisture is essential to the whole soil system because soil solution has nutrients needed for plant development [1], [2]. So, the key feature of the soil is soil moisture.

Detecting and measuring the correct soil moisture level is a popular method in irrigation. But most of the farmers do not have enough money to buy high priced devices. Giving the right volume of water to the soil needed large awareness and concentration to irrigate sandy soil. Putting excessive water enlarge pumping costs, decreasing water effectiveness, and cause contamination or pollutant. The greatest valuable resources of a plant is water and regularly becomes wasted because of ineffective systems [3]. So, irrigation needs a device that is low cost and efficient controlling of soil moisture [4].

Therefore, the study aims to develop an irrigation water management system that controls the volume and frequency of irrigation water applied to the soil and to develop a system that measures the soil moisture level using a low-cost sensor. Controlling the applied irrigation water to the soil regardings the measurement of the sensor to reduces excess water.

2. RELATED LITERATURE

This chapter covers the interrelated works that supported the irrigation control system.

2.1 Irrigation System

One study on irrigation management systems used an automatic water controller with the best usage of water that lessens power consumption and no excess water. The study used a low-cost microcontroller that obtain low-cost smart irrigation results [5].

Another study developed an irrigation system with fuzzy rules and the study used a device to measures the moisture and air temperature of the area, and YL-100 soil moisture sensor [6]. The study produced many rules that control the liquid pump for the system of the farm.

This proves that the soil moisture level is important and helps the irrigation system for many problems.

2.2 Soil Moisture

In the study of [7], Using watermark 200SS granular matrix water potential sensor to detect moisture content. The goal of the study is to provide an inexpensive sensor component to detect moisture content and conduct experiment to show the correlation between water potential and soil moisture volume.

Another study related to soil moisture sensors conducted by [8] goal is to develop a low-cost sensor from scratch. The study presents a process easy to create a device that measures soil moisture volume and conducts several testing samples of sensing to meet the significant accuracy. This evidence, controlling soil moisture volume is one of the best methods for regulating the soil state and to determine the water amount needed by the soil.

Another study by [9] uses wireless sensor networks (WSN) for irrigation systems that provide water resources to sustain and stabilize the soil moisture. The study used Gaussian process regression (GPR) to model the sensors to produce incorporated exteriors of soil moisture.

A smart irrigation system by [10] reduces human intervention and used a water controller. The study main goal is on the consumption of water that is supposed to be the main problem today. The study uses a device that computes or identify the soil moisture level and the system has a solenoid valve controlled by the Raspberry Pi microcontroller making the system compressed and maintainable.

According to the study of [11] that the solution for wastages of water is using a network sensor devices that measure the moisture level many parts of the farm. The study developed a cylindrical sensor called the IRRIS sensor is put into the ground to measure soil moisture volume with different depths. The study conducts several testing and comparative analysis of different designs to obtain an intelligent sensor.

One study by [12] uses data analytics to identify, interpret patterns, and present findings of agriculture. The study uses a discriminate analysis and Multi Linear Regression for the datasets of soil properties and water properties. The study develops a framework that predicts the cropping pattern for accomplishment supreme yield linked.

3. METHODOLOGY

3.1 Architecture of Automatic Irrigation System

Figure 1 illustrates the architecture of the proposed automatic irrigation system through controlled soil moisture measurement. The system has a moisture sensor act as the input device. This sensor needed a soil as an input activator. The system also has an output device like a liquid crystal display (LCD), buzzer, light-emitting diode, and water pump. The Arduino act as the brain that will control all the input and output devices.

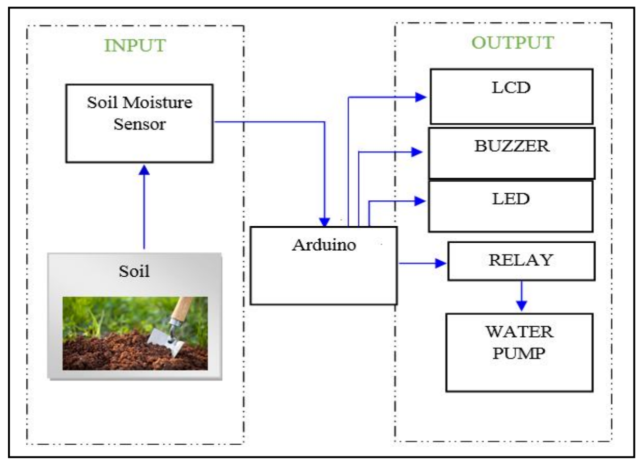

Figure 1: Architecture of Automatic Irrigation System

3.2 Circuit Diagram

Figure 2 shows the connection of the components needed on the automatic irrigation system. All components are linked to the digital and analog pins of the microcontroller Arduino.

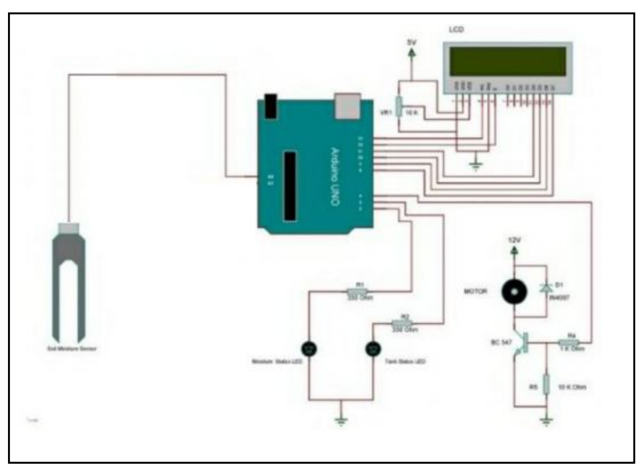

Figure 2: Circuit Diagram of Automatic Irrigation System

3.3 Materials and Components

To develop the Automatic Irrigation System through Controlled Soil Moisture Measurement, the following materials were utilized to develop the proposed system:

A. Arduino Uno

The Arduino UNO is a microcontroller board composed of an Integrated Chip ATmega328P microcontroller that was used by many studies [13]. In this microcontroller accepts data, process data, all decisions are taken and controlled what output will be display [14], [15]. Arduino UNO composed of analog and digital pins that will be useful for this irrigation system.

B. FC-28 Soil Moisture Sensor

The device place or dig through the soil then measures the water volumetric content called the moisture level [8]. The sensor can output both digital and analog values to the microcontroller. The sensor gives a value from 0 to 1023. The moisture content is measured in percentage values, so the system will map these values from 0 to 100.

C. Liquid Crystal Display (LCD)

The device is an interactive display screen with different applications to a project or study[13], [16]. LCD will be used as an output device for this study. This device will display the detected values of the sensors and alert messages.

D. Buzzer

Buzzer is used as an alarming device if the system detects that the soil moisture is high value meaning too much water on the soil.

E. Light Emitting Diode (LED)

LED is being used as an indicator of the system if the soil is needed to be irrigated; color is RED and LED color blue will turn on once the soil is already moistened.

F. Relay and Water Pump

Relay is used to enable the water pump when the system needs to apply water to the soil.

3.4 Sensor Readings

Here are the three (3) types of soil needed to be classified: Dry is a type of soil that is required for irrigation or apply water. Moistened is a type of soil that is being irrigated or no need for applying water. Last, Soggy is a type of soil that has too much water. So, the testing needed only the sensor and the Arduino UNO. The sensor output will be display using the serial monitor of the software Arduino IDE on the computer. The FC-28 Moisture Sensor output 0 to 100% processed by the microprocessor. The researchers conduct testing on the sensor to verify the soil type. In the testing, the researcher put the FC-28 sensor in the soil with 60 trials with different soil types: 20 soil for dry, 20 soil for moistened, and 20 soil for Soggy. This 60 sample of soils is being checked and classified using a market's device. Figure 3 illustrates and shows the outcome of the testing and verification of soil type. The x-axis shows the percentage value output of the sensors at 60% maximum while the y-axis shows the 60 trials with different soil types.

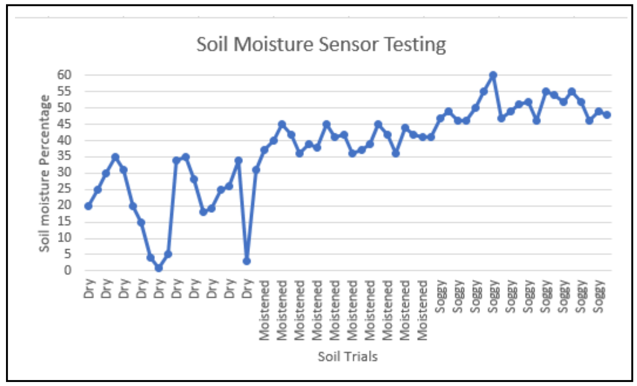

Figure 3: Soil Moisture Sensor Testing and Verification

Therefore, based on the testing and validation for the FC-28 soil moisture sensor and the market's device table 1 shows the classification of the type of soil and range of moisture levels.

Table 1: Soil Moisture Levels and Soil Type

Soil Moisture Level	Type of Soil
0% to 35%	Soil Needs to be Irrigated or "Dry"
36% to 45%	Soil is irrigated or "Moistened"
46% to 100%	Soil is "Soggy" or too much water content

3.5 Fuzzy Rule-Based

Fuzzy rule base is a database of rules and each rule is formed by "IF-THEN". A knowledge representation type used in Artificial Intelligence called a fuzzy rule base [17]. The IF part is conditional given information and in the THEN part is the action of the system [18]. To answer a problem, a rule offers some descriptions. Table 2 shows the fuzzy rules and actions.

Table 2: Fuzzy Rules

Rule No.	Condition	Action
1	IF moisture level <= 35 AND moisture level >=0 THEN	Display "Need to Irrigated" and Enable Water Pump
2	IF moisture level <= 45 AND moisture level >=36 THEN	Display "Moistened" and Disable Water Pump
3	IF moisture level <= 100 AND moisture level >=46 THEN	Display "Soggy" and Disable Water Pump

4. RESULT AND DISCUSSION

Functionality testing for the Automatic Irrigation System was done by the researchers to check if the hardware components and software performs as expected. Table 3 shows the software and hardware components testing.

4.1 Functional Testing

Table 3: Testing of Components

No.	Testing Activities
1	The sensor will be put on the soil and will measure the moisture level.
2	The Buzzer will alarm when the soil readings are “SOGGY”, LED RED will turn on, and LCD will output “SOGGY”.
3	LCD output “MOISTENED” when the soil reading is between 36% to 45%. And LED BLUE will turn on.
4	LCD output “DRY” when the soil reading is between 0% to 35% and the water pump will enable.

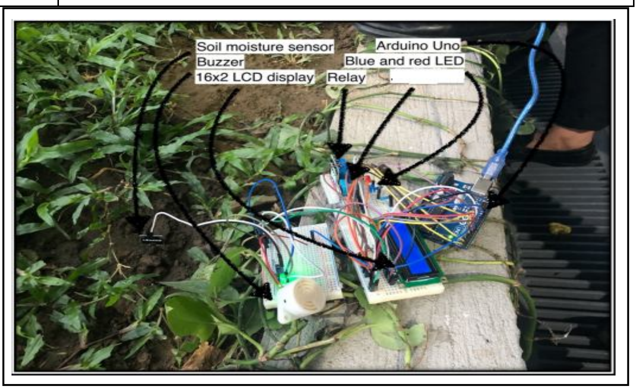

Figure 4: Functional Testing of the Components

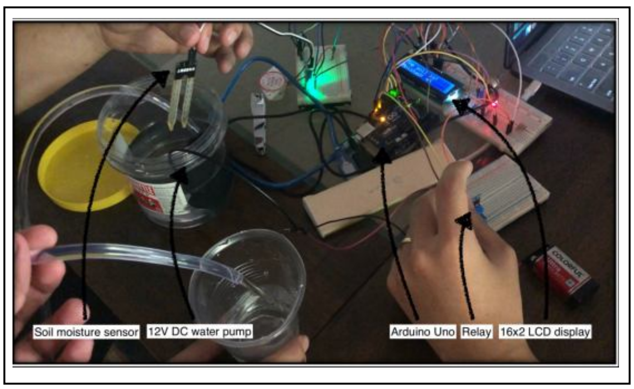

Figure 5: Functional Testing of the Water Pump and Sensor

Figure 4 and 5 shows the connection of the components in testing the Automatic Irrigation System. The researcher failed to provide a prototype and water tank for the storage of water because that is another problem to be solved in the next study if this paper will continue to be upgraded.

4.1 Testing and Result

To validate the whole system the researchers conducted 20 trials of testing to the Automatic Irrigation System. The system must measure the soil moisture level then classify the soil type and display it to the LCD. The testing was done in an indoor garden shows in Figure 6, putting the sensor in four (4) different parts of the garden and at a different time. Table 3 shows the testing result with 20 trials and shows the resulting success when the system does the expected output needed.

Table 3: Testing Result

No. of Trials	Time	Moisture Level	Soil Type	Result
1	7:00AM	5%	DRY	Success
2	7:01AM	15%	DRY	Success
3	7:02AM	25%	DRY	Success
4	7:03AM	20%	DRY	Success
5	1:00PM	36%	MOISTENED	Success
6	1:01PM	37%	MOISTENED	Success
7	1:02PM	34%	DRY	Success
8	1:03PM	33%	DRY	Success
9	2:00PM	29%	DRY	Success
10	2:01PM	30%	MOISTENED	Success
11	2:02PM	42%	MOISTENED	Success
12	2:04PM	42%	MOISTENED	Success
13	4:00PM	36%	MOISTENED	Success
14	4:01PM	37%	MOISTENED	Success
15	4:02PM	39%	MOISTENED	Success
16	4:02PM	40%	MOISTENED	Success
17	7:00PM	40%	MOISTENED	Success
18	7:01PM	44%	MOISTENED	Success
19	7:02PM	34%	DRY	Success
20	7:03PM	30%	DRY	Success

Figure 6: Indoor Garden Testing

5. CONCLUSION

In Irrigation, the issue of wastages of water and farmer can't afford the high price soil moisture sensor was extremely essential to be solved. Therefore, the automatic irrigation system through controlled soil moisture measurement using low-cost sensors becomes important for those who needed the system to aid the problems of farming. Tables 2 and 3 shows the conducted functionality testing and validation to the system resulted in a 100% success rate. This proves and demonstrates that the system is effective and efficient in the issue of soil irrigation. Improvement of the system can be done by adding a water tank to the system, network sensor, monitoring through cloud or IoT, and deep learning.

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