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An Economical Sensor-Based Automated Plant Watering System for Smart Irrigation

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Abstract:** Lack of water results in a reduction in photosynthesis in plants and crops. Plants are significantly affected when the soil water level is depleted thereby resulting in low production in the agricultural sector which can lead to a reduction in food supply. This problem makes water supply and management highly necessary for plants to grow effectively. Over the past century, the rate at which water usage has increased globally has increased at a rate higher than that of population growth. Particularly in dry regions, an increasing number of regions are now using more water than they can sustainably provide. The traditional watering techniques, such as sprinklers and flood mode, are ineffective and those not supply the ideal needs of plants because some plants do not need excess water to grow. This also results in water wasting. These ineffective irrigation systems often provide habitat for organisms that carry illnesses. Research has established that excessive water spillage and stagnant water can be habitat for mosquitoes which can also be dangerous to human health. Therefore, watering plants must be done intelligently, by developing an intelligent system that can regulate the content of water needed to water a plant in accordance with their needs and the moisture content of the soil. This will also reduce the spillage of water. In this study, an automated plant watering system that monitors the soil's moisture level to determine when watering plants is necessary was developed using hardware components such as Arduino UNO (Microcontroller), soil moisture sensor, pump, relays, wires, sprinkler and software instructions to drive the hardware components. An economical watering system was designed. The system was tested and can be effectively used in small gardens and big crop fields.

***Keywords:** Watering System, Arduino, Micro-Controller, Soil Moisture Sensor.*

1. INTRODUCTION

The majority of the significant losses in agriculture, whether they be material or monetary are related to the health and quality of the crops. A loss might occur if it turns out that the crops

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are not up to par. Crops must be kept in top condition and must be well preserved and moist in order to stop incurring losses in agricultural produce (Bhattacharya et al., 2021). For a farmer with big fields, it is almost difficult to supervise and maintain their farmland if manual methods are used to keep the soil moisture level in a desirable condition (Krishnan et al., 2020). Monitoring such fields with manual labourers poses a risk since many labourers choose to work in white-collar positions, leaving a significant shortage of workers. As a result, farming automation such as using automated irrigation systems is essential to achieve good throughput in farm produce. Improper irrigation is the main factor contributing to the crops' underperformance (other than natural calamities). Most of the problems will be remedied if the irrigation problems are fixed. This requires a technological revamp. Therefore, this study works on an approach of designing a sensor-based plant watering system for tracking and monitoring the soil texture, determining plants' needs in terms of water and agricultural potential making use of sensors to measure the soil's moisture level and controlling by an Arduino and microcontroller. This research aims to design an automatic plant watering device utilizing a soil moisture sensor. This system is expected to help farmers overcome problems in watering their crops by continuously monitoring the soil's temperature and moisture content, reducing farmer's manual intervention, and ensuring adequate moisture needed for plant growth.

2. RELATED WORK

In Kim and Evans (2009), Wireless in-field sensing and control software was designed by four major design factors that provide real-time monitoring and control of both inputs (field data) and outputs (sprinkler controls) by simple click-and-play menu using the graphical user interface and optimized to adapt changes of crop design, irrigation pattern, and field location. The software provides remote access to in-field micrometeorological information from the distributed wireless sensor network and variable-rate irrigation control. The work in Putjaikal et al., (2016), designed a control system for intelligent farming using Arduino technology. The methodology for this design is focused on the control part which are watering and roofing systems of an outdoor farm based on the statistical data sensed from the sensor systems (including temperature, humidity, moisture, and light intensity sensors) Since the sensed data would not be always accurate due to noises, they apply Kalman filtering to smooth the data before using as an input in the decision-making process. For the decision-making process, the sensed data was not only considered but also the weather information. A decision tree model is generated to predict the weather conditions. Then, a set of decision rules based on both the sensed data and the predicted weather condition is developed to automatically decide whether the watering and roofing system should be on or off.

In Taneja and Bhatia (2017), the authors developed a method to transform manual irrigation into automated irrigation, which will turn the pumping motor ON/OFF with the use of a soil moisture sensor that detects the moisture content of the soil. The microcontroller from the 8051 family is used by the authors to gather input signals that are transformed into measurements of soil moisture by soil moisture sensors, and it produces an output to switch on or off the water pump motor. Their solution uses a water level sensor to gauge the tank's level and ensure that it has enough water in it to effectively irrigate fields.

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3. METHODOLOGY

To achieve the goal of this study, hardware components and software components are employed. The hardware components used include Arduino UNO (Microcontroller), soil moisture sensor, pump, relays, wires, etc. The components are described below.

A. Hardware Components Used

- Arduino UNO

The Arduino Uno is one of the most popular boards in the Arduino series. As shown in Figure 1 below, Arduino is a microcontroller that can control buttons, LEDs, motors, speakers, GPS devices, cameras, the internet, and even your smartphone or television. Arduino is an open-source electrical platform built on the ATmega microcontroller. Its software, which is based on the C programming language and may be extended with C++ libraries, can run on Windows, Macintosh, and Linux operating systems. All other pieces of hardware in the system are connected to the Arduino, which receives signals from sensors and send signal to the sprinkler to irrigate.

Fig 1: Image of Arduino Uno

- Pump

A DC motor transforms direct current electrical power into mechanical power. This type of pump relies on the magnetic field's forces. For a portion of the motor's current to sometimes shift direction, almost all types of DC motors contain an internal mechanism that is either electromechanical or electronic. DC motor pump is a DC Motor that circulates water. The shaft of the DC motor is utilized to power an external arm that pumps water, and it is housed in a

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weatherproof plastic housing. Batteries or an AC source may readily provide the 5V supply needed for the Pump. An image of a DC motor pump is shown in Figure 2

Fig 2: DC Pump

- Relay

A Relay Module is a mains voltage electrically powered switch that may be turned on or off and can either allow current to flow through it or not. The relay-dependent relay module is seen in Figure 4. Relays are employed in the proposed system between the Arduino board and the water pump. These relays run on 5V DC power and act as switches for 220V AC when they get a trigger from the Arduino board. The Arduino board's I/O pins can operate the relay, which in turn can control the water pump.

- Jumper wires

A jump cable is used to connect the test plate, the prototype, or the internal circuit with other non-joined instruments.

- 9V Battery
- The battery is the DC source that supplies power to the system designed
- Soil Moisture sensor

Soil moisture sensors measure the volumetric water content in soil. A soil moisture sensor can measure the amount of moisture in the soil around it. This sensor uses the two probes to distribute current across the soil and then examines the resistance to determine the moisture level.

Extra water allows the soil to conduct electricity more easily (with less resistance), whereas dry soil does not (with more resistance).

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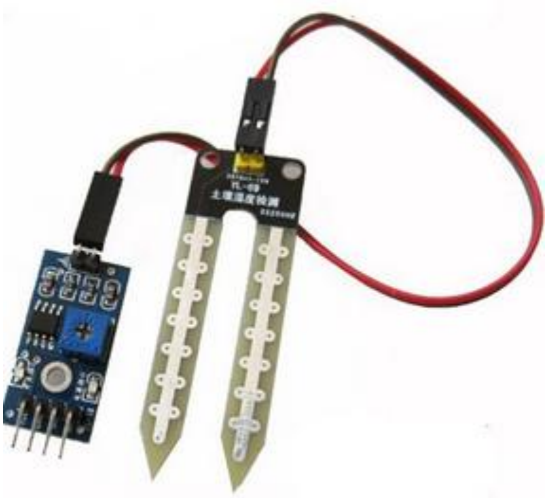

Fig 3: Image of a Soil Moisture Sensor

B. The Software

Software is a set of instructions, data, or programs used to operate computers and execute specific tasks. Software is a generic term used to refer to applications, scripts, and programs that can run on a device. It can be thought of as the variable part of the computer, while hardware is the invariable part. The Arduino UNO code for the watering system (Irrigation system) is written on the Arduino window and uploaded it to the I/O board as shown below.

```
const int waterPump = 4;   // assign the water pump pin to pin 4
const int moistureSensor = A0; // assign the moisture sensor pin to analog pin A0
int threshold = 700;       // set the threshold for watering
void setup() {
  pinMode(waterPump, OUTPUT);   // set the water pump pin as an output
  pinMode(moistureSensor, INPUT);  // set the moisture sensor pin as an input
  Serial.begin(9600);      // start the serial communication
}

void loop() {
  int soilMoisture = analogRead(moistureSensor);  // read the moisture level
  Serial.println(soilMoisture);   // print the moisture level
  if (soilMoisture < threshold) {
    digitalWrite(waterPump, HIGH);  // turn on the water pump
    delay(1000);    // wait for 1 second
    digitalWrite(waterPump, LOW);  // turn off the water pump
  }
  delay(1000);  // wait for 1 second before checking again
}
```

C. System Design

This section explains the procedures and methods used in the design and implementation of the system. This includes flow diagrams and illustrative circuit diagrams as depicted in Fig. 4 (a)

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& (b), and Fig. 5 respectively. The 5v of the Arduino is connected to the 5v of the relay module, the ground pin of the Arduino is connected to the GND of the relay, digital pin 3 is connected to the input pin of the relay, the GND pin of the moisture sensor is connected to Arduino's GND pin, the digital pin of the sensor is connected to pin 7 of Arduino and the pump is connected to the relay respectively.

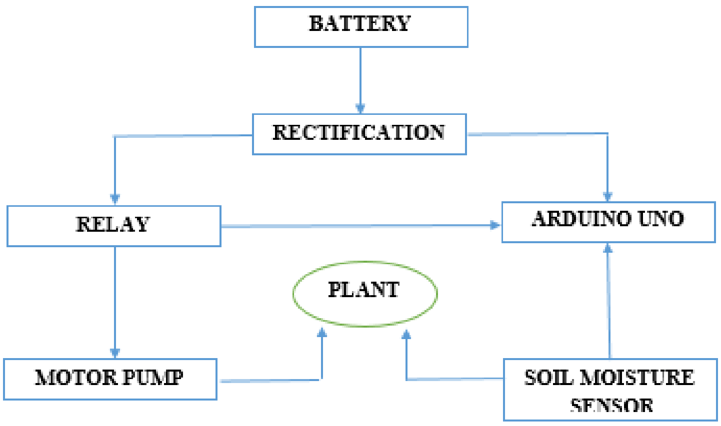

Fig. 4(a): The flow diagram of the designed system

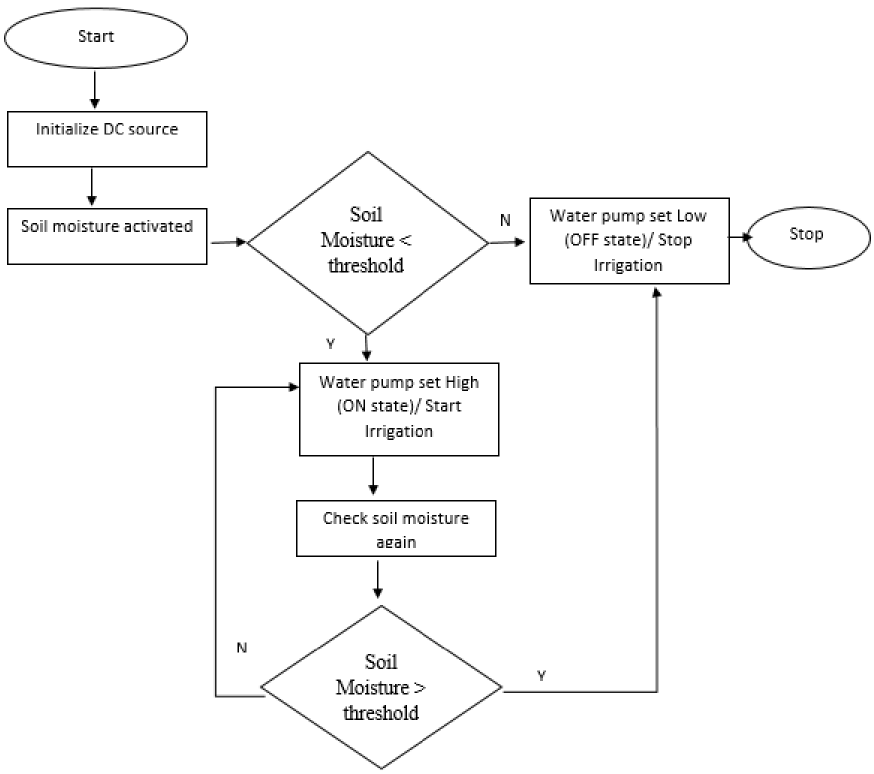

Fig 4(b): Flow Chart of the designed system

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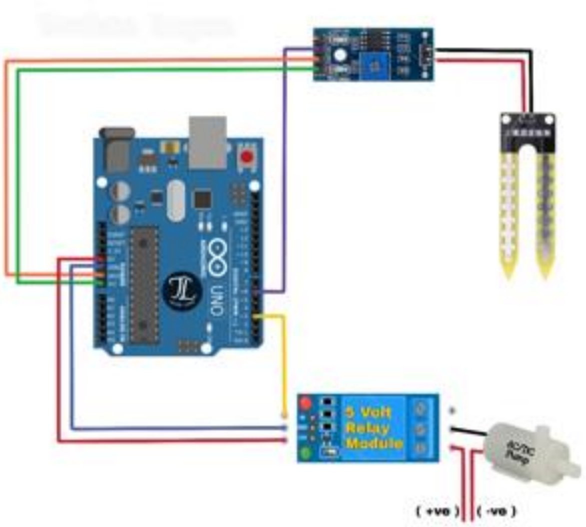

Fig. 5: Circuit Diagram of the designed system

4. RESULT AND DISCUSSION

The result of this work shows that if the soil moisture level is low, the moisture sensor will send a level 1 signal to the Arduino, which will then transfer the signal to a relay, turning on the motor pump and watering the plant. If the soil moisture level is high, the sensor will provide a level 0 signal and Arduino won't send any signal to the relay. Fig. 6 shows the display of the prototype of the designed system. The soil moisture content of farmland can be effectively managed using this design. When a signal is sent, the water pumping motor will automatically be switched on or off through a relay based on soil moisture. This saves water, while the water level may be reached in a favoured aspect of the plant, hence enhancing the yield of crops.

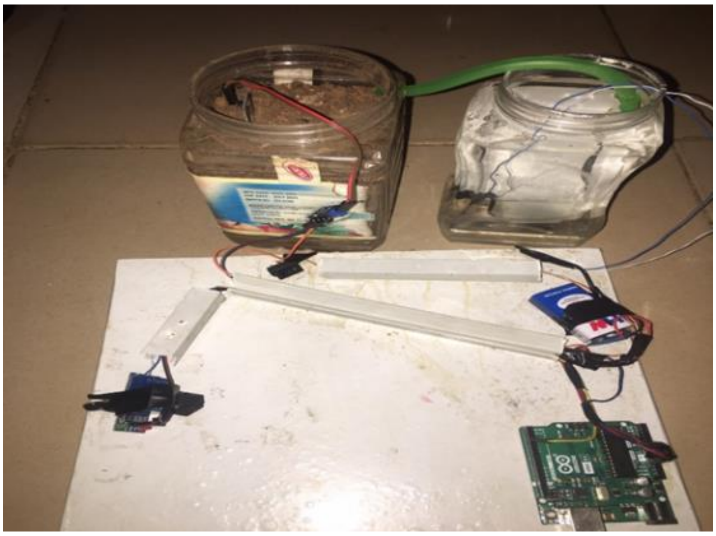

Fig. 6: The display of the prototype of the designed system

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For optimal absorption, a servo motor from vegetation water was evenly distributed in the water. As a result, there is less water waste. Based on the type of plant, the soil's moisture level, and the recorded temperature, the system also enables distribution to the plant when necessary. Major agricultural regions' efforts are minimized by the suggested work. The system can be modified in many ways, and software may be used to adjust it to specific needs within the facility. The outcome is a supporting technology that is scalable. We can determine if the soil is moist or dry with this sensor. The engine will automatically begin pumping water if it is dry.

5. CONCLUSION

A sensor-based watering system for smart irrigation capable of switching on/off water sprinklers for irrigation purposes was designed, implemented, and tested. To decide whether to irrigate the soil, the system uses soil moisture status from soil moisture sensors. The results of the system's testing revealed that its performance is quite reliable and accurate. It is economical and can be afforded by large-scale and small-scale farmers. The system includes adequate irrigation and can mitigate water wastage because watering will only be required when necessary. This will reduce water usage and also avoid flooding in the farmland. It will also aid in crop growth.

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