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| AIUB | | **American International University- Bangladesh (AIUB)**  **Faculty of Engineering (FE)**  **Department of Electrical and Electronic Engineering (EEE)** | | | |
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| **Course Name:** | | | Microprocessor and Embedded Systems | **Course Code:** | EEE 4103 | |
| **Semester:** | | | Spring 2023-2024 | **Section:** | E | |
| **Faculty Name:** | | | Protik Parvez Sheikh | | | |
|  | | |  |  |  | |
| **Capstone Project Title:** | | | Monitoring the Health of Plants and Implementing an Automated System for Watering Plants using Arduino. | | | |
| **Project Group #:** | | | 03 | | | |
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| **SL** | **Student Name** | | | **Student ID #** | | |
| **1.** |  | | |  | | |
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**Assessment Materials and Marks Allocation:**

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| **COs** | **Assessment Materials** | **POIs** | **Marks** |
| **CO3** | Course Project Report ***(Demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.)*** | **P.d.1.P3** | **5** |

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| **COs** | **Excellent to Proficient**  **[5- 4]** | **Good**  **[3]** | **Acceptable**  **[2]** | **Unacceptable**  **[1]** | **No Response**  **[0]** | **Secured Marks** |
| **CO3**  **P.d.1.P3** | The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research. | The outcome of the project somewhat demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc., and somewhat solves a complex engineering problem in the electrical and electronic engineering discipline through some research. | The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. but cannot solve a complex engineering problem properly in the electrical and electronic engineering discipline through appropriate research. | The outcome of the project does not demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. also could not solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research. | No Response |  |
| **Comments** |  |  |  |  | **Total Marks (5)** |  |

***Abstract— Conventional methods of plant care and watering encounter issues such as water wastage, inconsistent watering, and the oversight of terminating watering. These traditional approaches lack technological solutions to address these challenges. To overcome these issues, a system based on Arduino, equipped with specialized sensors, has been developed. These sensors assess parameters such as temperature and soil moisture to determine the optimal timing for watering plants. The automated system effectively prevents water and electricity wastage while ensuring plants receive the correct amount of water at the appropriate times. Additionally, the system facilitates data monitoring, essential for maintaining plant health. This report details the creation of this innovative system, outlining the utilization of Arduino and sensors to enhance plant well-being and minimize water waste. Furthermore, the report explores possibilities for future improvements, such as the integration of remote-control features to enhance usability.***

***Index Terms*—** **Automated Plant Watering, Plant Health Monitoring, Arduino UNO, Water Wastage, Temperature Monitoring, Soil Moisture Detection, Optimal Watering Cycles.**

# I. INTRODUCTION

## A. Background and Motivation

Ensuring plants receive the appropriate amount of water is crucial for their optimal growth and water conservation. However, conventional watering methods often lead to water wastage and may negatively impact plant well-being. Additionally, these methods lack automation, potentially resulting in inadequate watering when needed or excessive water supply when overlooked. Forgetfulness in turning off the water further contributes to overwatering, leading to unnecessary electricity consumption.

We propose a smart solution to address these challenges—a system designed as an intelligent aid for plants. Employing advanced technology, this system will accurately determine when plants require water and in what quantity. This approach ensures that plants remain content and healthy without unnecessary water and energy consumption. Essentially, it aims to provide plants with precisely the right amount of water at opportune moments.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Standard Data of Plant | | | | |
| Plant | Soil Moisturizer (%) | Temperature (degree Celsius) | Humidity (%) | Water Temperature (degree Celsius) |
| Tomato | 41 | 20-30 | 50-70 | 15-25 |
| Aloe vera | 31 | 18-27 | 30-50 | 18-25 |

## B. Project Objectives

• Creating and deploying an automated plant watering system with Arduino UNO, leveraging real-time data from environmental sensors for intelligent water regulation.

• Designing a monitoring system that exhibits room temperature, humidity, water temperature, and soil moisture readings, delivering transparent plant health information to users.

• Incorporating a relay control mechanism to proficiently oversee the watering motor, ensuring accurate and timely water delivery to plants.

• Assessing the system's real-world performance through comprehensive testing, gauging its effectiveness in sustaining robust plant growth while minimizing water consumption.

• Raising awareness of sustainable plant care practices by highlighting the advantages of intelligent irrigation contributes to fostering a culture of resource-efficient gardening and agriculture.

## C. Outline

1. Abstract
2. Introduction
3. Literature Review
4. Methodology and Modeling
5. Results and Discussions
6. Conclusion and Future Endeavors
7. References

# II. Literature Review

There is lots of work that is already done using Arduino to implement an automated plant watering system.

* Nine orchards were tested during 2018 using linear regression (LR), random forest regression (RFR), and support vector regression (SVR) methods. The results obtained lead to the conclusion that these methods are valid engines to develop automatic irrigation scheduling systems [1].
* A survey is done to focus on smart irrigation systems in water-scarce regions. It covers soil and weather monitoring, communication technologies, data management, low-cost sensors, sustainable practices, and future challenges, offering insights into efficient water usage and agriculture optimization [2].
* Unfortunately, due to poor management, loss of climate control, and overuse of water, there can be heavy losses of up to 40% for crops grown in greenhouses. The Arduino microcontroller system has proven to be reliable when installed in large greenhouses and the system saves approximately 12.5% of the water normally used in these greenhouses. Additionally, the linear model was chosen as the best model to use in greenhouses, with the average accuracy percentage simulation and mean square error being 92.038 and 0.01988%, respectively [3].
* The abstract introduces an automated plant watering system that utilizes a microcontroller and moisture sensors to regulate watering based on soil moisture levels, aiming to simplify plant care and enhance water efficiency. The system's components, methodology, and benefits, including water conservation and adaptability, are discussed in detail [4].
* There is a paper that presented a detailed, up-to-date review of the state-of-the-art role of IoT in water distribution systems. It presented the taxonomy of the water distribution system and role of IoT technologies, architectures, cloud platforms in various water distribution applications. It proposed an IoT architecture for intelligent water networks: IoTA4IWNet, for real-time monitoring which is relevant to our project [5].

# III. Methodology and Modeling

*A. Introduction*

The Plant Monitor System presented here combines technology and nature, enabling us to create an environment that promotes healthy plant growth through accurate monitoring and automated care. By utilizing various sensors, relays, and an Arduino microcontroller, this system aims to maintain optimal conditions for different types of plants by regulating temperature, humidity, and soil moisture levels.

*B. Working Principle*

1. **Temperature and Humidity Monitoring:** Using a DHT22 sensor, the system gauges ambient temperature and humidity, instantly revealing plant conditions on an LCD and via Arduino's serial communication.
2. **Soil Moisture Measurement:** Analog soil moisture sensors determine soil dampness, converting data to percentages displayed on the LCD.
3. **Water Temperature Sensing:** A DS18B20 sensor in water tracks temperature, factoring into watering schedules to prevent plant stress.
4. **Automated Watering System:** Controlled by relays, two water pumps cater to distinct plant groups with specific moisture needs. Pumps activate when soil moisture dips below limits, considering water temperature.
5. **LCD Display:** Real-time insights, encompassing temperature, humidity, soil moisture, and water temperature for plant categories, are easily accessible via an LCD screen.

*Process of Work:*

A computer screen shot of a computer

Description automatically generated

*Figure: Circuit Diagram*

*Hardware Setup:*

1. Gather the Components:

* Arduino board (e.g., Arduino Uno)
* DHT22 temperature and humidity sensor
* DS18B20 temperature sensor
* Two soil moisture sensors (analog)
* Two water pumps (relays)
* Liquid Crystal Display (LCD)
* Jumper wires
* Power supply (12V)

2. Connect the Components:

* Connect the DHT22 sensor to pin 13 on the Arduino.
* Connect the DS18B20 sensor to pin 12 on the Arduino.
* Connect the two soil moisture sensors to analog pins A0 and A1 on the Arduino.
* Connect the water pump relays to digital pins 8 and 9 on the Arduino.
* Connect the LCD using the provided pin connections (rs, en, d4, d5, d6, d7).

*Software Setup:*

1. Install Arduino IDE:

- Download and install the Arduino IDE from the official website (https://www.arduino.cc/en/Main/Software).

*2. Install Libraries:*

- Open the Arduino IDE.

- Go to "Sketch" > "Include Library" > "Manage Libraries..."

- Search for and install the following libraries: "DHT", "OneWire", "DallasTemperature", and "LiquidCrystal".

*3. Upload the Code:*

- Copy and paste your provided code into the Arduino IDE.

- Connect your Arduino board to your computer using a USB cable.

- Select the correct board and port under the "Tools" menu.

- Click the "Upload" button to upload the code to the Arduino board.

*Testing:*

1. Open Serial Monitor:

- Once the code is uploaded, open the Serial Monitor by clicking the magnifying glass icon in the upper right corner of the Arduino IDE. Set the baud rate to 9600.

2. Observe Readings:

- You should see temperature, humidity, soil moisture, and water temperature readings displayed in the Serial Monitor.

- Ensure that the LCD is displaying the initial message and the sensor values on each row.

3. Test Water Pump Logic:

- Check the Serial Monitor to see if the pumps are being turned on and off based on the defined conditions (soil moisture and water temperature).

*Troubleshooting:*

1. Check Wiring:

- Make sure all connections are secure and correctly placed according to the hardware setup section.

2. Verify Libraries:

- Double-check that you've installed the required libraries correctly.

3. Sensor Issues:

- Verify that the sensors are functioning properly. Test them individually if needed.

4. Serial Monitor Output:

- If you're not getting the expected readings or pump control, carefully review the code logic and conditions.

5. Power Supply:

- Ensure that your power supply provides stable voltage and current to the components.

6. Serial Communication:

- If you don't see any output in the Serial Monitor, ensure you've selected the correct COM port and baud rate.

7. LCD Display:

- If the LCD is not displaying as expected, check the wiring, and ensure the LCD library is being used correctly.

8. Pump Control:

- Make sure the relay connections are correct and the pumps are receiving power.

9. Environmental Factors:

- Ensure the sensors are placed correctly and are not affected by external factors that could skew readings.

*C. Description of the Components*

**Micro JST 1.25mm 2-Pin Male to Female connector:**

Description: Small connector for various connections.

Quantity: 2

**Jumper Wires (M to F) 20 Pieces:**

Description: Connects components on the breadboard.

Quantity: 1

**Jumper Wires (M to M) 20 Pieces:**

Description: Connects components on the breadboard.

Quantity: 3

**12V 5A Power Adapter:**

Description: Supplies power to the system.

Quantity: 1

**2.1mm Barrel Type Female DC Power Jack:**

Description: Power connector.

Quantity: 1

**1 Channel Relay (5V):**

Description: Controls water pump operation.

Quantity: 2

**Breadboard:**

Description: Prototyping platform for circuit testing.

Quantity: 1

**LCD Display (20 x 4) with Header:**

Description: Shows real-time data and system status.

Quantity: 1

**Solar Water Pump:**

Description: Delivers water to plants.

Quantity: 2

**Waterproof DS18B20 Digital Temperature Sensor:**

Description: Monitors water temperature.

Quantity: 1

**Soil Moisture Sensor:**

Description: Detects soil moisture levels.

Quantity: 2

**D11T22 Temperature and Humidity Sensor:**

Description: Measures room temperature and humidity.

Quantity: 1

**Arduino UNO R3:**

Description: Microcontroller board for controlling the system.

Quantity: 1

A close-up of a device

Description automatically generatedA table with electrical components

Description automatically generated with medium confidence*D. Test/Experimental Setup*

*Figure: Setup of equipment’s*

# IV. Results and Discussions

*A. Experimental Results*

Motor 1: Tomato plant

Motor 2: Aloe vera plant

|  |  |  |  |
| --- | --- | --- | --- |
| Soil Moisture(%) | Water Temperature | Motor number | Status |
| 60 | 25 | Motor 1 | Off |
| 60 | 25 | Motor 2 | Off |
| 45 | 25 | Motor 1 | Off |
| 45 | 25 | Motor 2 | Off |
| 40 | 25 | Motor 1 | On |
| 40 | 25 | Motor 2 | Off |
| 30 | 22 | Motor 1 | On |
| 30 | 22 | Motor 2 | On |
| 35 | 30.1 | Motor 1 | Off |
| 25 | 30.1 | Motor 2 | Off |

This table indicates the activation status of the motors at appropriate times. For instance, when the moisture level reached 40% and the water temperature was 25 degrees, the motor activated. This decision was based on the standard data table, which indicated that the tomato plant was not in an optimal condition, prompting automatic watering. The displayed humidity and temperature data enables users to make informed decisions for enhancing plant health, thereby achieving the project's objectives successfully.

*D. Cost Analysis*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | **Items** | **Quantity** | **Rate (BDT)** | **Amount (BDT)** |
| 1 | Micro JST 1.25mm 2-Pin Male to Female connector | 2 | 34.9 | 69.8 |
| 2 | Jumper Wires (M to F) 20 Pieces | 1 | 56.9 | 56.9 |
| 3 | Jumper Wires (M to M) 20 Pieces | 3 | 56.9 | 170.7 |
| 4 | 12V 5A Power Adapter | 1 | 297.8 | 297.8 |
| 5 | 2.1mm Barrel Type Female DC Power Jack | 1 | 32.5 | 32.5 |
| 6 | 1 Channel Relay (5V) | 2 | 84.8 | 169.6 |
| 7 | Breadboard | 1 | 155.83 | 155.83 |
| 8 | LCD Display (20 x 4) with Header | 1 | 470 | 470 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 9 | Solar Water Pump | 2 | 349.9 | 699.8 |
| 10 | Waterproof DS18B20 Digital Temperature Sensor | 1 | 549.7 | 549.7 |
| 11 | Soil Moisture Sensor | 2 | 140.6 | 281.2 |
| 12 | D11T22 Temperature and Humidity Sensor | 1 | 375.5 | 375.5 |
| 13 | Wire | 3 | 20 | 60 |
| 14 | Supply Pipe | 2 | 60 | 120 |
| 15 | Arduino UNO R3 | 1 | 845 | 845 |
| Total | | | | 4650.33 |
| Including Discounts and Shipping | | | | **4514.14** |

*E. Limitations in the Project*

While the automated plant watering system provides effective solutions for plant care issues, it does have specific limitations. Notably, the system currently lacks remote functionality, limiting users from watering plants and monitoring sensor data remotely. The absence of these features diminishes the system's overall utility by impeding user convenience and accessibility. Furthermore, the system lacks a mobile or computer interface, which could significantly improve user interaction. Recognizing these limitations emphasizes the opportunity for further refinement and expansion of the system's capabilities to better meet user requirements.

# V. Conclusion and Future Endeavors

The creation and application of the automated plant watering system signifies a notable advancement in tackling issues related to plant care and irrigation. The incorporation of environmental sensors, decision-making algorithms, and automation mechanisms highlights the system's capacity to refine watering practices and improve plant health. Despite the valuable benefits offered by the current system, some limitations have been observed, particularly in terms of the absence of remote functionality and a user interface, constraining the system's overall usability and convenience.

*Future endeavors:*

* **Remote Connectivity**: Introducing remote access capabilities would allow users to water plants and monitor sensor data from a distance, enhancing user convenience and enabling real-time adjustments.
* **User-Friendly Interface**: Developing a user-friendly application for mobile or computer platforms would empower users to effortlessly manage and monitor the system, fostering a seamless and interactive experience.
* **Data Analytics**: Incorporating data analytics could enable predictive insights and adaptive watering strategies, ensuring even more precise and efficient plant care.
* **Integration of IoT**: Exploring the integration of Internet of Things (IoT) technologies could extend the system's reach, enabling seamless communication between devices and enhancing overall system intelligence.
* **Energy Efficiency**: Optimizing energy consumption and exploring alternative power sources, such as solar energy, could contribute to sustainable and eco-friendly operation.

The automated plant watering system serves as a foundation for smarter and more efficient plant care. By addressing its current limitations and embracing future technological advancements, the system can evolve into a comprehensive tool that not only simplifies plant maintenance but also contributes to sustainable agricultural practices and environmental stewardship.

# References

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