NATIONAL UNIVERSITY FAIRVIEW
College of Engineering and Technology
Bachelor of Science in Information Technology
with Specialization in Mobile and Internet Technology

Efficient Plant Watering Using an Arduino-Based Automatic Irrigation System

A Programming Embedded Systems presented to the faculty of

Bachelor of Science in Information Technology

In partial fulfillment of the requirements for

PEMBEDS – PROGRAMMING EMBEDDED SYSTEMS

Leading to the degree of

Bachelor of Science in Information Technology

with Specialization in Mobile and Internet Technology

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A. THE PROBLEM AND IT'S BACKGROUND

Introduction

This study aims to develop an efficient plant watering system using moisture sensors. The project automates the process of plant watering by continuously monitoring soil moisture levels and dispensing water accordingly. Previously, the project was done with the help of an Arduino uno, but the development team found a better and a more convenient way to make the project without the Arduino uno. Standalone projects are better in terms of power as they use AA batteries that allow for portable and independent power. This allows projects to operate without relying on continuous external power or being constrained by outlets, increasing versatility and flexibility. The system's efficiency is evaluated by measuring the amount of water consumed and comparing it to the amount of water typically required for manual watering. The study also evaluates the system's accuracy in maintaining optimal soil moisture levels for various plant species. Results show that the Arduino-based automatic irrigation system is efficient in conserving water while maintaining optimal soil moisture levels for different plant species. The study concludes that the project can be an effective solution for automating the process of plant watering in agricultural and horticultural applications.

Background of the Study

Water is a fundamental requirement for the growth and survival of plants. The proper management of water resources is necessary to maintain plant health and productivity. In agriculture and horticulture, efficient irrigation systems are essential to conserve water, reduce labor costs, and improve crop yields.

Manual watering of plants is time-consuming and labor-intensive, especially for large plantations. Traditional irrigation systems are often wasteful and inefficient, leading to waterlogging, soil erosion, and over-watering. Additionally, climate change and droughts have intensified the need for effective water management practices in agriculture. The advancement of technology has paved the way for the development of automatic irrigation systems that can save water, reduce labor costs, and improve crop yields. One of the most promising technologies for automatic irrigation is the use of microcontrollers such as Arduino.

This study aims to develop an efficient plant watering system using an Arduino-based automatic irrigation system. The system will utilize soil moisture probes to detect the moisture content of the soil and control a submersible pump to water the plants when the soil moisture falls below a pre-set threshold. The study will evaluate the performance of the system in terms of water efficiency, labor savings, and plant growth compared to traditional manual watering methods.

The results of this study will contribute to the development of efficient and sustainable irrigation systems for agriculture and horticulture. It will also provide insights into the potential benefits of using Arduino-based automatic irrigation systems for plant watering.

Significance of the Study

The significance of this study lies in its potential to address the challenges associated with manual plant watering, such as over-watering or under-watering, which can lead to plant stress, poor growth, and reduced yield. The project, based on moisture sensors, can automate the process of plant watering and optimize water usage. By ensuring the plants receive adequate water at the right time, the project can improve plant growth, increase yield, and reduce water wastage. Moreover, the project is cost-effective and can be implemented in various agricultural and horticultural settings, such as greenhouses or outdoor plantations. The study can also pave the way for future research in the field of precision agriculture and the development of smart irrigation systems.

Statement of the Problem

The manual process of plant watering is inefficient and prone to errors such as over-watering and under-watering, leading to plant stress and reduced yield. Traditional irrigation systems do not optimize water usage and can result in water wastage. There is a need for an automated plant watering system that can efficiently water plants and optimize water usage to improve plant growth and increase yield. Moreover, current automated irrigation systems are expensive and not accessible to small-scale farmers or home gardeners. Therefore, there is a need to develop a cost-effective, Arduino-based automatic irrigation system that can be easily implemented in various agricultural and horticultural settings.

Objective

The study aims to design and develop an irrigation system that can efficiently water plants based on their specific requirements, and to test its effectiveness in providing the appropriate amount of water to plants, using an Arduino-based automatic system.

Specific Objectives

- Develop and construct an Arduino-based automatic irrigation system with accurate soil moisture measurement and real-time data monitoring.

- Create a user-friendly interface for customizable watering schedules, optimizing water usage efficiency, and incorporating sustainable features.
- Conduct thorough testing, documentation, and evaluation to ensure reliability, replication, and effectiveness of the irrigation system.

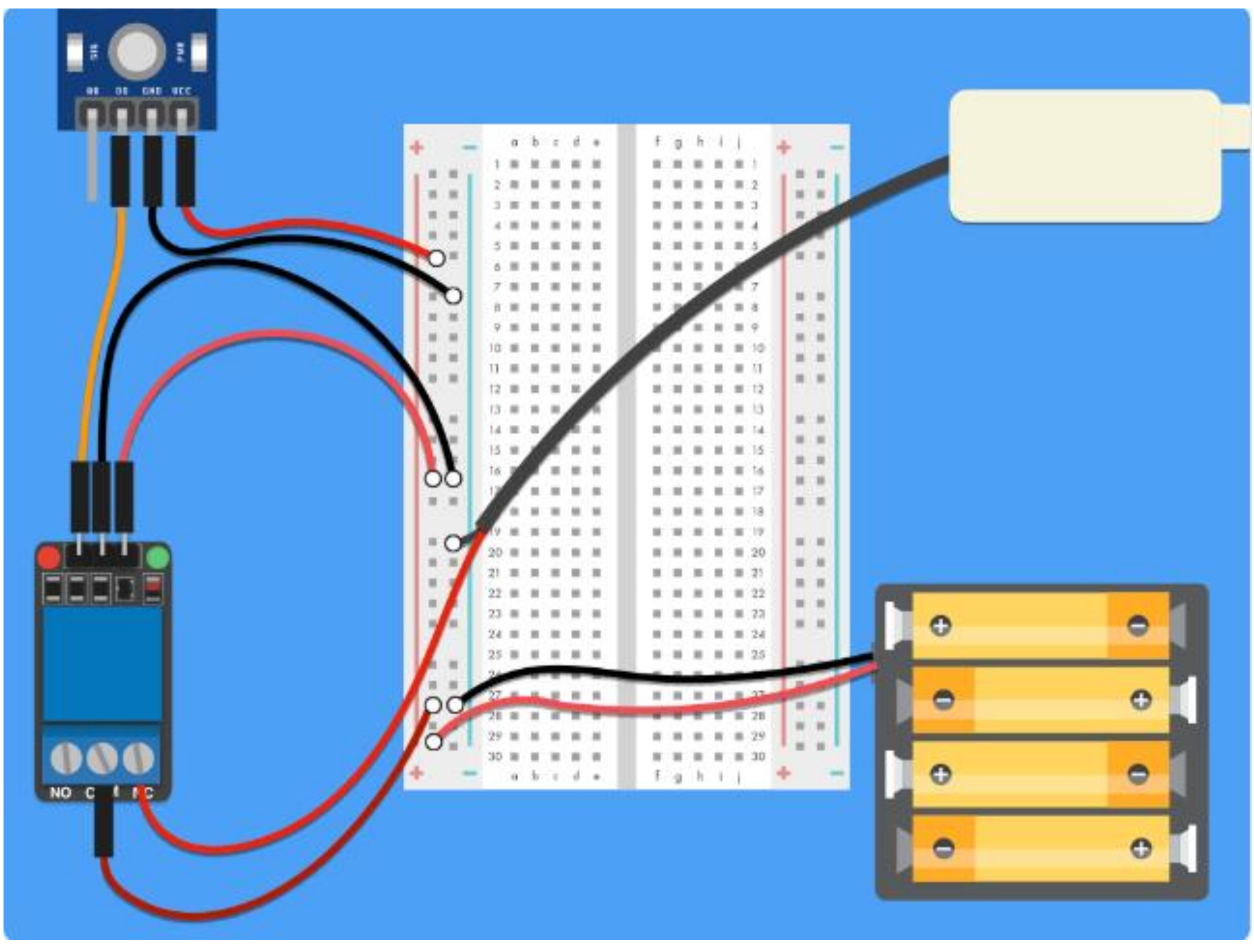
Scope and Limitation

The scope of the study is to design and develop a prototype irrigation system using Arduino technology to efficiently water plants. The study will focus on testing the system's ability to provide the appropriate amount of water to plants based on their specific requirements, and to monitor soil moisture levels to ensure efficient water usage. Whilst the study aims to design and develop an Arduino-based automatic irrigation system to efficiently water plants, with a limited scope of testing the system's effectiveness for a specific number of plant species and environmental conditions, and without addressing economic, social, ethical or legal aspects of implementation or adoption.

B. RELEVANCE

The project "Efficient Plant Watering Using an Arduino-Based Automatic Irrigation System" holds significant relevance in addressing specific Sustainable Development Goals (SDGs), namely SDG 6: Clean Water and Sanitation and SDG 15: Life on Land. By implementing an innovative irrigation system that accurately measures soil moisture levels and optimizes water usage, the project aligns with SDG 6's objective of ensuring clean water availability and sustainable water management. By preventing water wastage through over-irrigation, the system promotes water efficiency, contributing to SDG 6's target of sustainable water use. Moreover, the project directly contributes to SDG 15 by supporting life on land. Through efficient plant watering, it helps maintain healthy vegetation, preserves ecosystems, and promotes sustainable land management practices. The system's ability to provide plants with the precise moisture levels they require contributes to SDG 15's goal of biodiversity conservation and sustainable land use. By addressing specific aspects of water management and land stewardship, this project demonstrates its practical relevance within the broader context of SDGs 6 and 15.

C. TECHNICAL ASPECTS



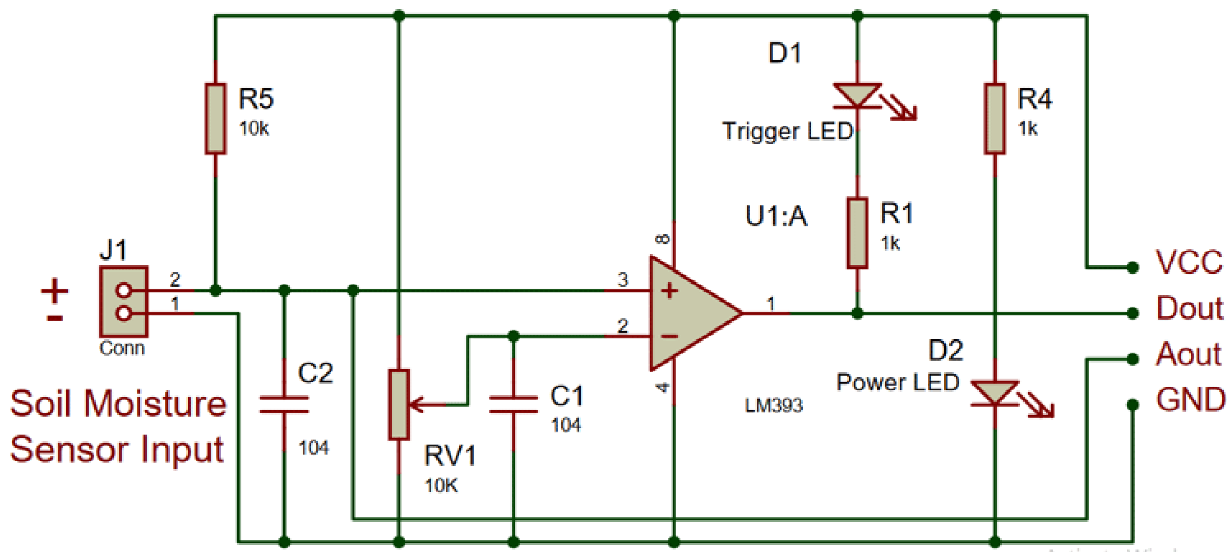
Component Name	No. of Pieces	Description/Value
5V Relay Module	1	The relay module is used to control the power supply to the submersible pump. It switches the pump on and off as required.
Soil Moisture Probes	1	The soil moisture probes are used to detect the level of moisture in the soil.
Comparison Module	1	The comparison module is used to compare the moisture level detected by the probes with a pre-set threshold. The module sends a signal to switch on the submersible pump if the soil moisture falls below the threshold.
Small Submersible Pump	1	The submersible pump is used to water the plants. It is switched on and off via the relay module.
Tube	1	The tube is used to transport water from the submersible pump to the plant.
Breadboard	1	A flexible platform for temporary circuit connections where components such as relay modules and comparison

		modules can be easily inserted and connected using jumper wires.
Battery Pack Enclosure	1	The battery pack enclosure houses the batteries that power the pump and the other components.
AA Batteries	4	The AA batteries power the other components, allowing the system to operate autonomously.
Jumper Wires	13	Jumper wires are used to connect the various components of the system together, the soil moisture probes, the relay module, and the submersible pump.

Complete Datasheets for Digital Devices

1. Soil Moisture Sensor Module
   - Operating Voltage: 3.3V to 5V DC
   - Operating Current: 15mA
   - Output Digital - 0V to 5V, Adjustable trigger level from preset
   - Output Analog - 0V to 5V based on infrared radiation from fire flame falling on the sensor
   - LEDs indicating output and power
   - PCB Size: 3.2cm x 1.4cm

- LM393 based design
- Easy to use with Microcontrollers or even with normal Digital/Analog IC
- Small, cheap and easily available

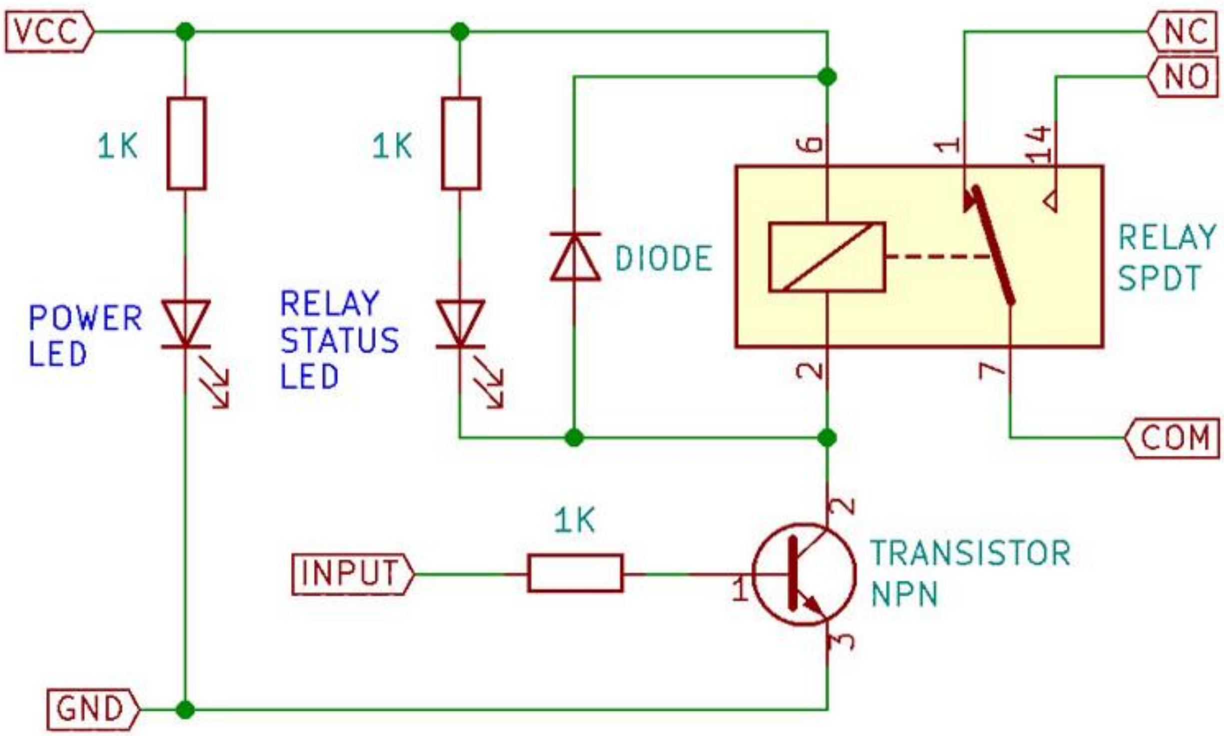


The soil moisture sensor module consists of 4 pins. H. VCC, GND, DO, AO. The digital output pin is connected to the output pin of the LM393 comparator IC and the analog pin is connected to the humidity sensor. The internal schematic of the humidity sensor module is shown in the figure above.

Using the sensor module with a microcontroller is very easy. Connect the module's analog/digital output pins to the microcontroller's analog/digital pins. Connect the VCC and GND pins to the 5V and GND pins of your microcontroller. Then insert the probe into the ground. More water in the soil means more current flow, lower resistance, and higher water content.

2. 5V Relay Module
    - Supply voltage – 3.75V to 6V
    - Quiescent current: 2mA

- Current when the relay is active: ~70mA
- Relay maximum contact voltage – 250VAC or 30VDC
- Relay maximum current – 10A



The figure above is the internal circuit diagram for the 5V relay module. The reason there is an additional component besides the relay is that it cannot be driven directly from a microcontroller pin. This is because even though the coil draws far less current than it can switch, it still requires a relatively large amount of current. Low power relays consume about 50mA, while high power relays consume about 500mA. The coil is also an inductive load, so turning off the coil can generate a large flyback voltage that can damage the device when turning it on and off. For this reason, a flyback diode is added antiparallel to the relay coil to limit the flyback voltage. An LED can be added to this basic circuit to act as an indicator, and sometimes opto-isolation is added to the input to improve isolation.

Code

The project of the development team is a standalone and will not be using an Arduino. This code is applicable if an Arduino is used for the automatic plant watering irrigation system. This will monitor the time it takes to water and how long will it wait for it to water again if the moisture level is below a certain amount. Serial outputs will also be showcased.

```
int motorPin = 3; // pin that turns on the motor

int blinkPin = 13; // pin that turns on theLED

int watertime = 5; // how long it will be watering (in seconds)

int waittime = 1; // how long to wait between watering (in minutes)


void setup()

{

  pinMode(motorPin, OUTPUT); // set Pin 3 to an output

  pinMode(blinkPin, OUTPUT); // set pin 13 to an output

  Serial.begin(57600);

}


void loop()

{

  int moisturePin = analogRead(A0); //read analog value of moisture sensor

  int moisture = ( 100 - ( (moisturePin / 1023.00) * 100 ) ); //convert analog value to
percentage

  if (moisture < 70) { //change the moisture threshold level based on your calibration values
```

```
    Serial.println("Moisture level is: " + String(moisture));
    Serial.println("Motor is On");
    digitalWrite(motorPin, HIGH); // turn on the motor
    digitalWrite(blinkPin, HIGH); // turn on the LED
    delay(watertime * 1000);      // multiply by 1000 to translate seconds to milliseconds
  }
  else {
    Serial.println("Moisture level is: " + String(moisture));
    Serial.println("Motor is Off");
    digitalWrite(motorPin, LOW);  // turn off the motor
    digitalWrite(blinkPin, LOW);  // turn off the LED
    delay(waittime * 5000);      // multiply by 60000 to translate minutes to milliseconds
  }
}
```

Serial Monitor

```
Moisture level is: 49
Motor is On
Moisture level is: 48
Motor is On
Moisture level is: 45
Motor is On
Moisture level is: 45
Motor is On
Moisture level is: 76
Motor is Off
Moisture level is: 71
Motor is Off
Moisture level is: 70
Motor is Off
Moisture level is: 69
Motor is Off
Moisture level is: 42
Motor is On
```

D. CAPABILITIES & LIMITATIONS

Capabilities

- **Sensor-based monitoring**: The project integrates various sensors, such as soil moisture sensors and temperature sensors. These sensors provide real-time data about the environmental conditions, allowing the system to make informed decisions about irrigation requirements.
- **Precise irrigation scheduling**: With the help of sensors and programmed algorithms, it can determine the optimal irrigation schedule based on the specific needs of the plants or crops. It can adjust the watering frequency and duration to ensure that the plants receive the right amount of water at the right time.
- **Water-saving features**: Automatic irrigation systems using soil-moisture sensors can help conserve water by avoiding overwatering. By monitoring soil moisture

levels, the system can prevent watering when the soil is already adequately moist. It ensures that water is used efficiently and minimizes wastage.

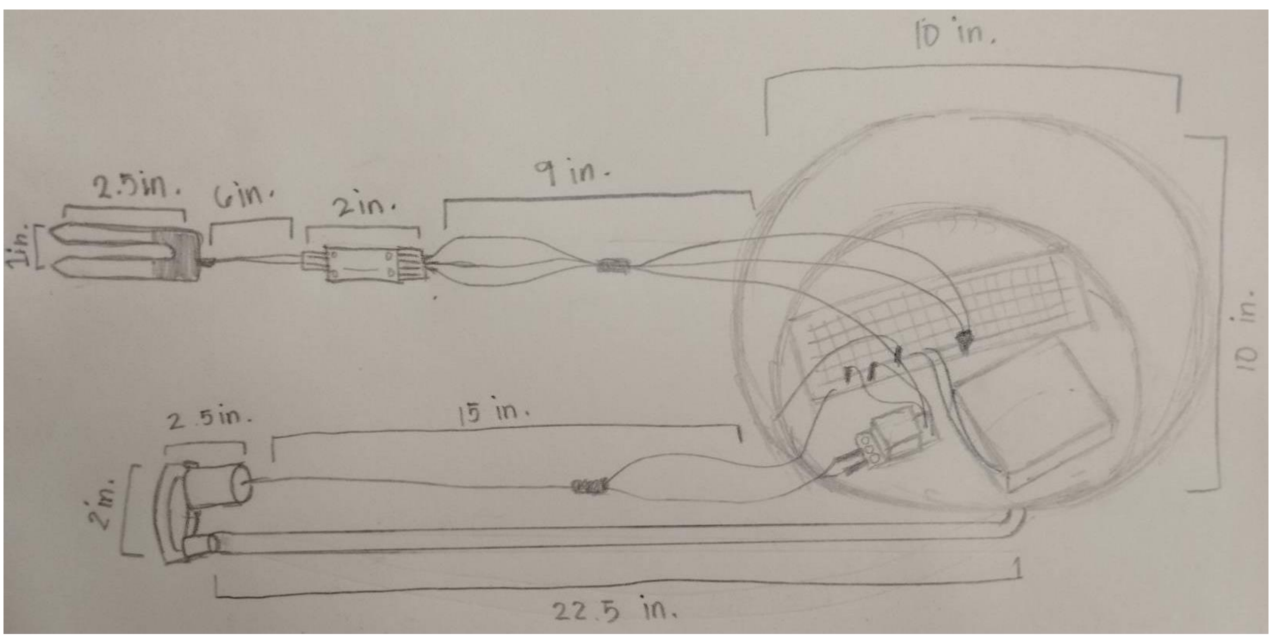
- **Energy-efficient operation**: The Arduino-based project is designed to be energy-efficient, consuming minimal power during operation. This allows the irrigation system to run for extended periods without draining excessive power, making it suitable for off-grid or low-power scenarios. Adaptability to different plants: The Auto Plant Watering kit components do not explicitly address customization for different plant species. Additional programming and adjustments may be required to cater to individual plant needs.
- **Expandability and modularity**: The system is designed with expandability in mind, allowing for the addition of more sensors, actuators, or modules to enhance functionality. It supports a modular approach, making it easier to integrate new features or scale up the system as needed.
- **Low maintenance requirements**: The system is designed to be low maintenance, with features such as self-cleaning mechanisms for sensors, easy-to-replace components, and robust construction to withstand outdoor conditions.

Limitations

- **Limited scalability**: The 5V Relay Module and jumper wires provided in the kit allow for a limited number of plants to be monitored and watered simultaneously.
- **Watering precision**: The accuracy of the soil moisture probes and the comparison module included in the kit may vary, potentially leading to overwatering or underwatering of plants.

- **Power supply**: The battery pack enclosure and USB power line provided in the kit offer a power source for the small submersible pump. However, these power options may limit the system's flexibility in outdoor environments or areas without easy access to electricity.
- **Maintenance requirements**: Regular maintenance and calibration of the system, including the soil moisture probes and the pump, are necessary to ensure accurate sensor readings and proper functioning.
- **Adaptability to different plants**: The Auto Plant Watering kit components do not explicitly address customization for different plant species. Additional programming and adjustments may be required to cater to individual plant needs.

E. BLUE PRINT / LAYOUT



F. PROTOTYPE

The Auto Plant Watering kit prototype utilizes the components mentioned above. The 5V Relay Module acts as a switch, controlling the power supply to the small submersible pump. The soil moisture probes, along with the comparison module, measure the moisture content of the soil. When the moisture level falls below a specific threshold, the relay is triggered, allowing power to flow to the pump. The 50cm tube is connected to the pump to deliver water from a reservoir or container to the plant's soil.

The battery pack enclosure and USB power line serve as power sources, providing electricity to the pump. The kit may also include jumper wires to establish connections between different components.

However, it's important to note that the prototype has limitations. The number of plants that can be monitored and watered at once depends on the limitations of the 5V Relay Module. The accuracy of the soil moisture probes and comparison module may vary, affecting the precision of watering. The power options provided by the battery pack enclosure and USB power line may restrict the system's use in certain environments. Regular maintenance and calibration are necessary for optimal functioning, and customization for different plant species may require additional programming and adjustments beyond the components provided in the kit.

References:

Cherie Tan, Automatic Plant Watering with Arduino. Learn to set up an automatic plant watering system with the Arduino. https://littlebirdelectronics.com.au/guides/4/automatic-plant-watering-with-arduino