Project Proposal

ELG 4139 - Electronics III

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School of Electrical Engineering and Computer Science

University of Ottawa

Ekin Berktay 300237014

Tristan Ruel 300272156

Paul Karakach 300238050

Group 38

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Literature Review

Introduction

In today's world, efficient water usage is becoming increasingly important, especially in agriculture and landscaping. Today we are going to be taking a look at a system that optimizes performance and efficiency for plant growth. Our project is called the " Smart Garden" and it will provide the customer with a more efficient and optimised way to water their plants/grass. The main reasoning behind this is that rather than most general time-based systems out there. We are aiming to design a sensor-based system which will give us a more up-to-date situation in our garden. Optimized plant growth, resource efficiency, and remote monitoring are going to be some of the options that our product will have which can take an edge over the other products in the industry.

Project Summary - Sensors

For this design, we are going to have 4 sensors that we are going to implement into our product, these will be:

- Temperature Sensor - DHT221
- Humidity Sensor - DHT221
- Soil Moisture Sensor - Adafruit Water Level Sensor
- GPS (Location Sensor) - Neo 6m

What we are aiming to do with these 4 sensors is to optimize water usage and find the best optimal time to water our garden depending on the results that we get from these 4 sensors.

Our temperature and humidity sensor will be coming 2-in-1 and their aim is to measure the surrounding temperature and humidity of the garden. Our goal will be to place these near the plants at plant height but not directly in contact with them. The main reasoning behind this is that we are trying to avoid the microclimates that might skew our results when we are trying to record our readings. Placing these near the plants and putting them on plant height will be important so we can take the perspective of the plant and grass in terms of how they sense the temperature.

Soil moisture sensor will be a critical sensor as we will need to measure the amount of moisture our plants have at the root level. The sensor can activate the sprinkler depending on the soil's dryness and deactivate once the soil has reached the appropriate moisture level. The placement of this sensor will ideally be at the root-depth level as we are going to need to measure the moisture from the perspective of the roots. For this garden, we are assuming that we are focusing mainly on shallow-rooted plants which are things like herbs, lettuce, grass, etc. The root depth for these plants ranges from 4-6 inches deep so this depth will be ideal for our soil moisture placement.

Lastly, GPS is a location sensor that we will be trying to implement in our smart garden. The main purpose of this will be to get online access to weather information specific to the positioning of the GPS. The main benefit of this will be to double-check the values that we receive for the humidity and temperature values and detect sun positioning for optimal sunlight exposure analysis. (e.g., sunrise, sunset times, sun elevation angle). We can also take these into account when deciding when to water our garden to get an even more efficient and optimized result.

Microcontroller

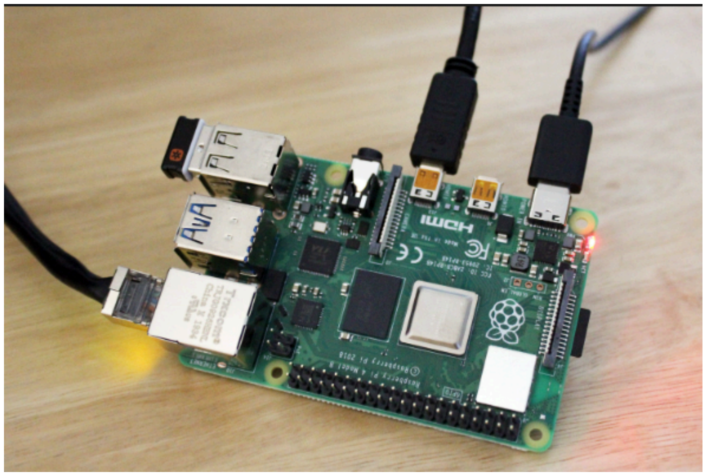

Figure 1: Raspberry Pi 4

We are going to use the Raspberry Pi 4B 2Gb model to process our design. The reasoning behind this is that there is just simply more processing power, and flexibility for coding languages to implement the project with. Along with that, some of the other benefits include.

- Multitasking → Several sensors running at once
- Storage Capacity → Store more data from the sensors
- Networking and Connectivity → It will be easier for us to connect to the cloud

The cons would be the cost of using a Raspberry Pi 4 model, higher power consumption, and slower boot time due to the operating system. After considering these cons, we thought that specifically for our projects and the sensors that we are using, a Raspberry was deemed to be more impactful compared to the Arduino.

Data Storage & Cloud

Since we are using a Raspberry Pi, it will be easy to store data as we can store it locally in a CSV file. A Python script will be sufficient to configure data at regular intervals depending on our liking. For the storage, we are going to use Google Cloud to upload our locally stored data onto the cloud. To do this, we are going to need access to Google Cloud Console. To do this, using Google Sheets API to authenticate our Raspberry Pi with Google Sheets.

We think that cloud storage will be beneficial to us as we can collect historical data over the years, and we acn use this information to time the watering of our garden and track trends over long periods of time.

Article 1 - An IoT based Smart Monitoring and Controlling System for Gardening

This article talks about an IoT based product that has very similar traits to ours.

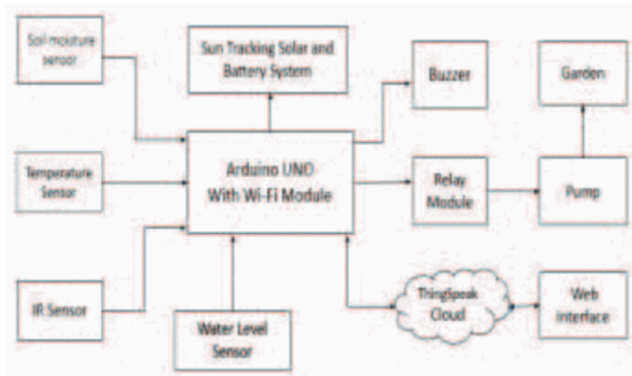

Figure 2: Block Diagram for a Smart Garden IoT System

From the picture above, we can see the same concept being applied with multiple sensors measuring soil moisture, temperature sensor, and water level sensors all being connected to an Arduino UNO Microcontroller. From there, Arduino will store the data to the ThingSpeak Cloud platform and actiavting the water pump depending on the readings from the sensor.

This is a similar to concept to ours but the concept of watering is a bit different. Here, we can see that the microcontroller controls the water pump which waters the plants. On our design, our microcontroller will control relays which then activate sprinklers, Our system is more lenient towards lawns with larger areas which might have a more competitive advantage in the industry.

Article 2 - Understanding RTDs, Thermocouples, and Thermistors

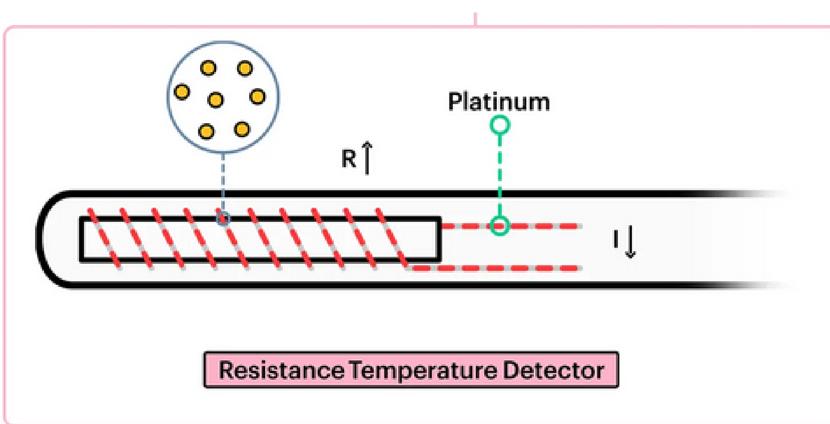

Figure 3: RTD Temperature Sensor Diagram

This article talks about the widely used temperature sensors. Mainly talking about their differences and in what applications it's being used. RTDs also known as Resistance Temperature Detectors, mainly work with a wire that is made out of Platinum. When this metal gets heated, the vibration on an atomic level slows down the electron mobility and therefore the resistance. This sensor relates the temperature with the amount of resistance the wire has at a particular moment.

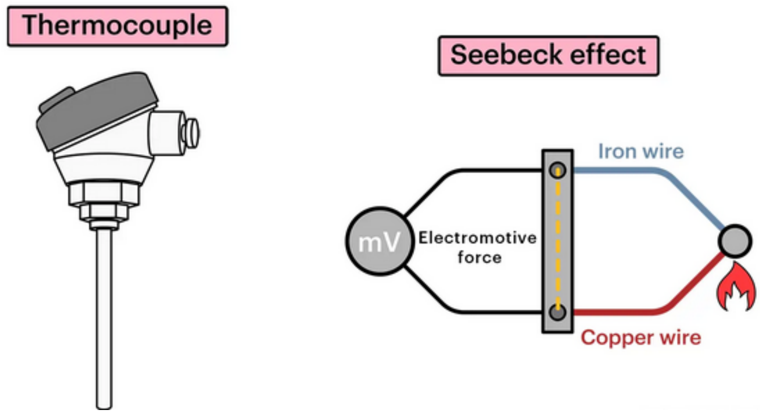

Figure 4: Thermocouple Sensor Diagram

The figure above demonstrates how a thermocouple sensor operates. It operates on the *Seebeck Effect* where if you heat up one end of the circuit and connect metals with different conductivity to it. There will be an electromotive force acting between them which will give off a voltage reading which is directly proportional to the temperature.

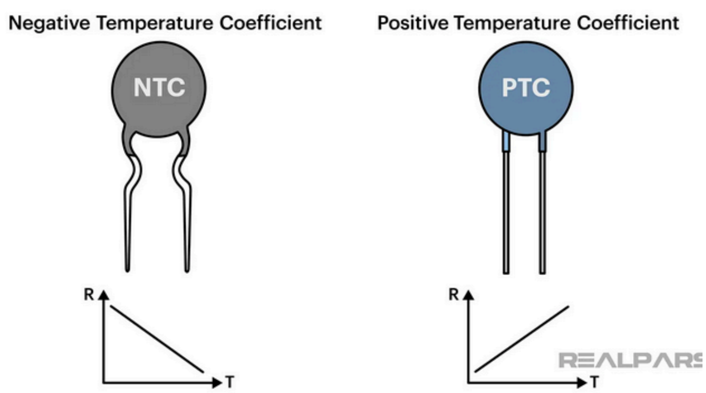

Figure 5: Thermistor Sensor Diagram

Lastly, the most common method of a temperature sensor would be a thermistor. Simply put, it detects temperature based on the level of resistance at any given point. The two types are PTC and NTC, NTC is the most used in the industry. The reasoning behind why thermistors are the most used is because of their cost efficiency, sensitivity to small temperature changes, and fast response. Our sensor will most likely be equipped with a thermistor as it will cover small ranges of temperature.

Article 3 - Soil Moisture Techniques and Factors

This article talks about ways to collect data on soil moisture.

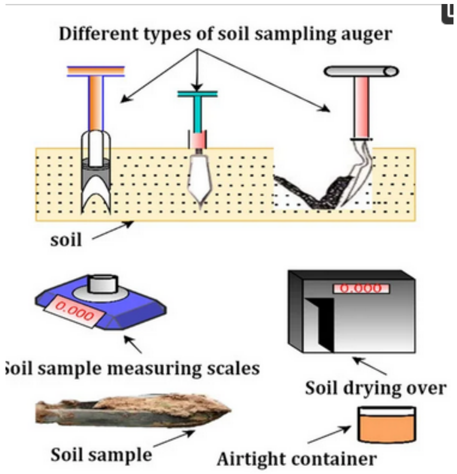

Figure 6: Thermistor Sensor Diagram

This common process involves removing a soil sample to measure its water content but weighing it normally, drying it in the oven, and then weighing it again. This method doesn't allow for repetitive measures as it is a destructive method and it is very time-consuming.

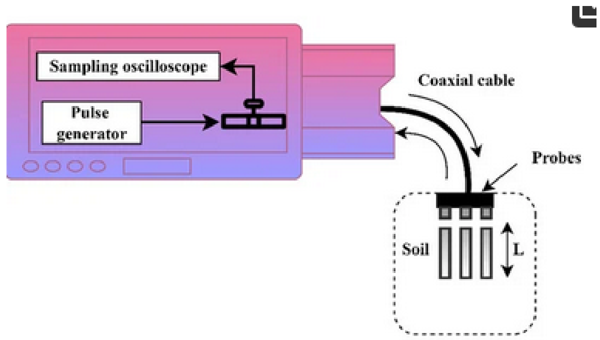

Figure 7: Time Domain Reflectometry (TDR)

This laboratory and irrigation management-based measuring relies heavily on electromagnetic waves and the time it takes to travel through the soil. This change in time relates directly to the moisture content. Since it is a laboratory-based measuring, initial setup will be time-consuming along with it being very expensive.

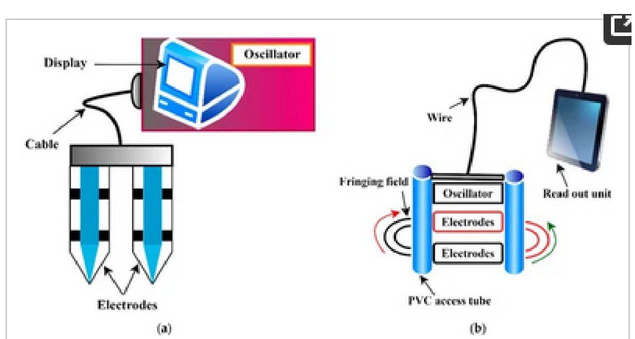

Figure 8: Capacitive Sensors

These are the most commonly used sensors in irrigation systems and smart gardens. This sensor detects soil moisture by measuring the changes in the capacitor and detecting the medium's dielectric constant which is directly related to the water content of the soil. It is a very cheap setup and is a very popular IoT-based application. Its results might not be as accurate compared to that of the TDR.

There are many other methods that can be used to detect soil moisture but these seem to be the ones that are really commonly used and give a very good idea of the water content of the soil. For our project, capacitive sensors seem to be the best case in terms of measuring the moisture of the garden.

Block Diagram

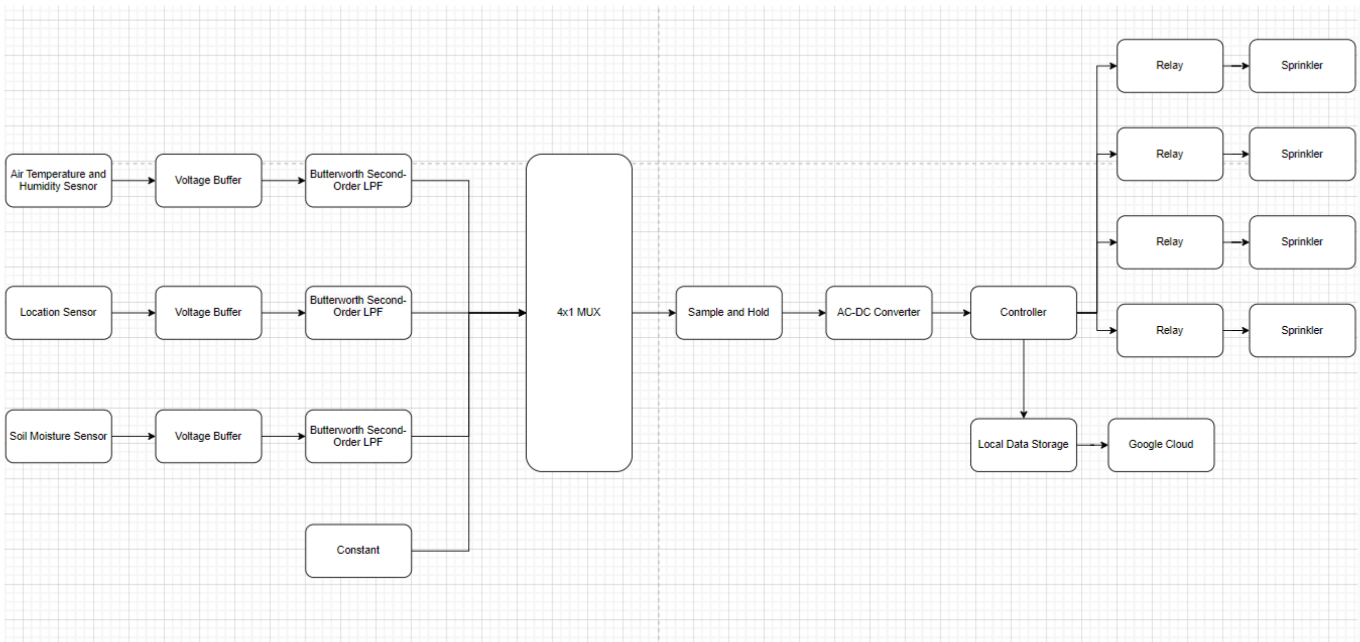

Figure 9: Block Diagram

Conclusion

To conclude, our Smart Garden project promises to utilise advanced technological integration and intelligent sensor use. By leveraging a combination of temperature, humidity, soil moisture, and GPS sensors, coupled with the computational power of the Raspberry Pi 4, this system aims to optimise water usage and enhance plant growth efficiency effectively. The smart integration of these sensors enables the system to make data-driven decisions, ensuring that plants receive the right amount of water at the most opportune times. Furthermore, by storing and analysing sensor data on the cloud, the Smart Garden allows for continuous improvement and remote monitoring, offering a tailored gardening experience that adjusts to both environmental conditions and user preferences. As we continue to face global challenges related to water scarcity and environmental sustainability, the development of such smart systems not only supports individual gardeners but also has the potential to contribute to broader ecological conservation efforts.

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keywords: {Temperature sensors;Wireless communication;Water;Wireless sensor networks;Temperature;Soil moisture;Humidity;Water Level;Temperature;Humidity},