AUTOMATED PLANT WATERING SYSTEM

Embedded Systems Development

Capstone Project

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Abstract

This project is an addition to a previous ESD capstone project for detecting soil moisture titled, *"Plant Growth Monitoring System"*. This project will add a new feature by detecting soil moisture, and automatically watering the plant based on its requirements. This project is an initial step to bringing automation to plant growth. Plant growth requires monitoring and controlling key elements such as light exposure, atmosphere temperature and humidity, and supplying sufficient water. This project's main focus is to provide sufficient amount of water to the plant based on the user input of soil moisture requirements.

1. Introduction

Growing indoor potted plants is widely enjoyed hobby amongst a large variety of consumers. There are professionals who have great experiences and knowledge, and know exactly what each and every one of their plant requires. Each plant will have its own specific requirements like light exposure, ambient temperature and humidity, and soil moisture levels. For an amateur plant grower, this can be a difficult task. To explore a few examples. Orchids need ample water but soil needs to dry out before the next watering, and needs high atmosphere humidity. African violets can't be left standing in water or get completely dry and need medium intensity light. Succulents on the other hand do not like "wet feet", can be left dry for few days, and require half to full day of light. How will one know how to manipulate all these conditions to the exact requirement of the specific plant one wishes to grow? This project explores this problem by proposing an automated solution to this problem.

Plant growth requires monitoring and controlling key elements such as light exposure, atmosphere temperature and humidity, and supplying sufficient water to the plant. This project's main focus is in supplying sufficient water to the plant based on the user input of soil moisture requirements specific to the plant. The other key elements such as ambient light, temperature and humidity will also be monitored and reported to the user.

2. Existing Solutions

There are a few solutions that currently exists for this problem. An example is the Aero Garden by AeroGrow (*Figure 2.1*). This system grows plants using hydroponics method. The consumer can buy various seed pods and insert them into the garden and fill the tank with water and nutrients. The Aero Garden will then automatically provide correct amount of light and nutrients to the plant without consumer interference. In few weeks, the plants will sprout.

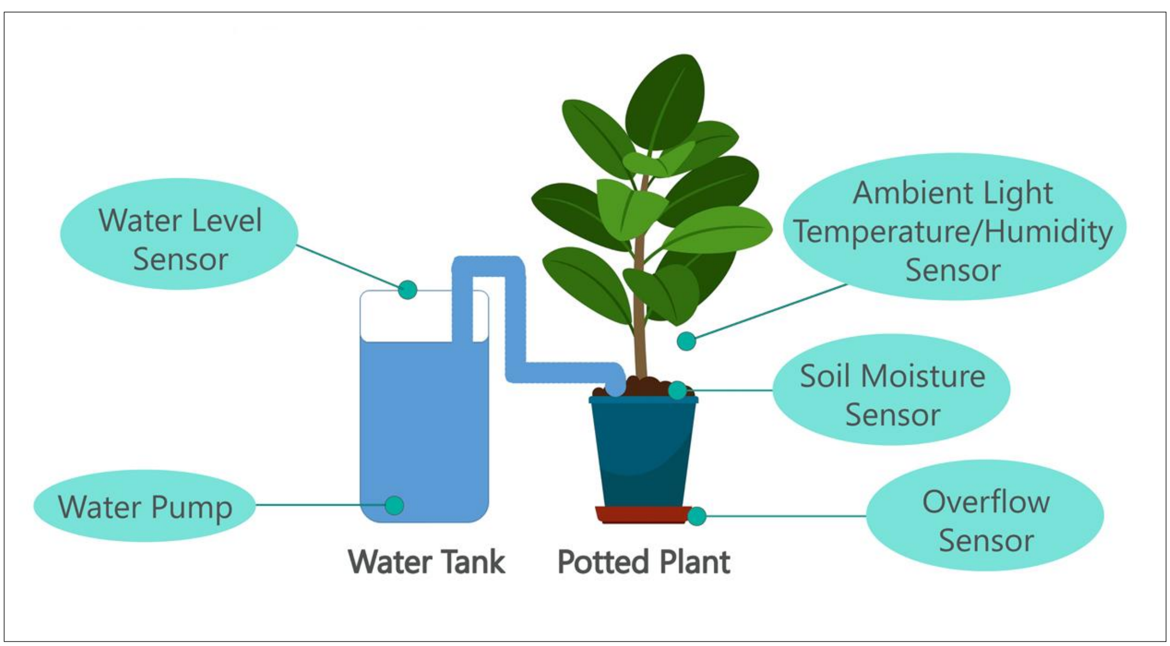
Figure 2.1: Aero Garden by AeroGrow

This system however does not provide feedback data to the consumer. Even though it automatically provides light and water to the plants, there is no way to monitor whether its enough or not. This system also only works best for Hydroponics gardening, where soil is not required (For Ex. Herb Garden). This specify system cannot be used on any plants. Most decorative plants are grown in soil.

3. Proposed Solution

The design overview of the solution to this problem is shown in *Figure 3.1*. The solution requires an embedded system which will monitor inputs from various sensors and make decisions based on requirements set internally and by the user. The key elements being monitored are soil moisture, and ambient light, temperature, and humidity. Water is supplied to the plant based on soil moisture requirements through a water pump. Additional sensors are included to monitor water level in the supply tank, and detect overflow of water from the pot.

Figure 3.1: System Design Overview



4. Technology

MCU – Arduino Uno

Figure 4.1: Arduino Uno

ATmega328P based open source microcontroller developed by Ardunio.cc. The Uno has 14 Digital pins, 6 Analog Pins, programmed with Arduino IDE. It can be powered through a USB cable or externally from a voltage source varying from 7 to 20V.

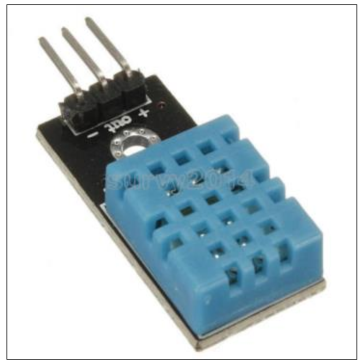
Soil Moisture – Capacitive Soil Moisture Sensor

Figure 4.2: Capacitive Soil Moisture Sensor

Capacitive soil moisture sensors prove to be more suitable than resistive sensors due to the avoidance of corrosion. Corrosion can affect the plants life as well as working life of the sensor. This sensor can be connected directly to an ADC input on the MCU to read moisture values.

Temperature / Humidity – DHT11

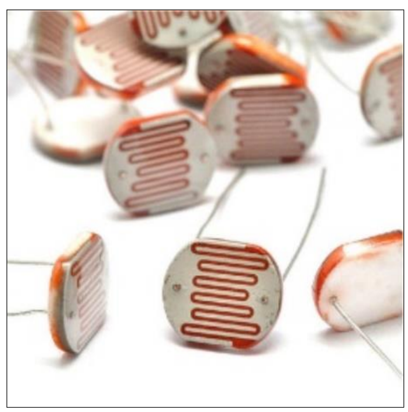
Figure 4.3: DHT11



DHT11 is a great sensor to use in indoor conditions to measure temperatures ranging from 0°C - 50°C with an accuracy of ±2℃, and relative humidity measuring from 20% 0 90% with accuracy of ±5%. The DHT11 has a readily available library for the Arduino Uno and can read values for temperature and humidity through a digital pin.

Light – GL12528

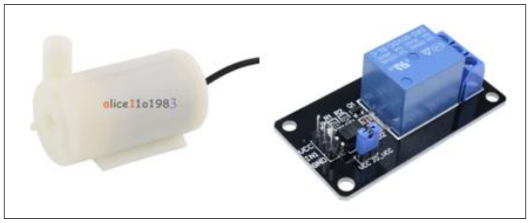
Figure 4.4: GL12528



A widely used 12mm photoresistor in many industrial applications. It is very cost effective and reliable.

Water Supply – DC Motor Pump

Figure 4.5: DC Motor Pump + 5V Relay



A 3-6V operating range DC motor water pump which is submersible in water. The pump has a water outlet which can be connected to a tube to supply water to the plant. This pump requires an external power supply which will provided through a USB charger and controlled by a 5V relay.

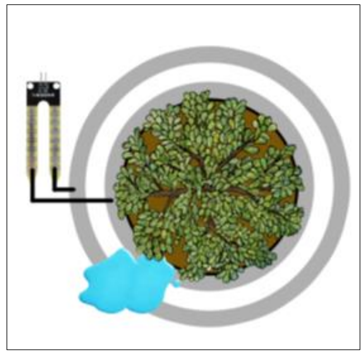
Water Level – HCSR04

Figure 4.6: HCSR04 + Setup

An ultrasonic sensor with a detectable range from 2cm to 400cm. The sensor will be attached to the top of the water supply tank as shown in *Figure 4.6*.

Over flow – Resistive Sensor

Figure 4.7: Overflow Sensor Setup



To detect water overflow from the pot, a resistive sensor will be used. The prongs of the sensor will be connected two conductive surfaces at the base of the pot as shown in *Figure 4.7*.

GUI

The graphic user interface is simple Python script run interface controlled through the Arduino serial port. As seen in *Figure 4.8* the GUI includes a debug screen (1), moisture level setting (2), operating mode selection (3), live sensor monitoring (4) and over flow and water level monitoring (5).

Figure 4.8: GUI

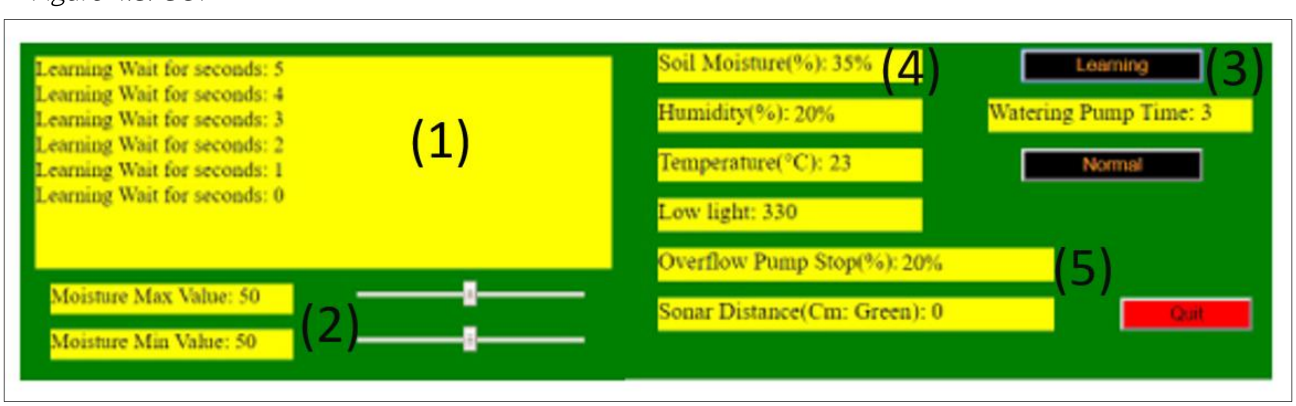
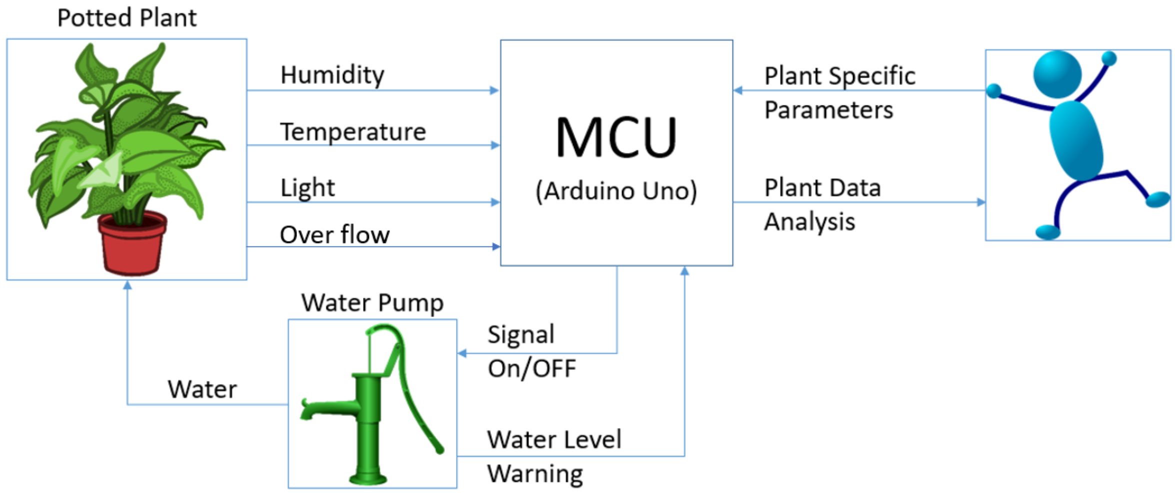


Figure 5.1: High Level Architecture



5. Methodology

This section will discuss the key features of this solution. The high-level architecture is shown in *Figure 5.1.*

Intelligent Pot Size Learning:

In order to provide water for the plant, the amount of water needed is a necessary information. This can vary based on pot size. Larger pots will require long watering times and smaller pots will require shorter watering times. This system is setup to learn the size of the pot at initial setup before starting regular functionality.

When the user initiates the learning mode through the GUI *Figure 5.1(3)*, the system will start pumping water for 3 seconds, then wait for 1 minute to see if there has been an increase in soil moisture. The system will continue this cycle until an increase in soil moisture is detected, storing the total time it took. This time will be the duration that the system will use to pump water to the plant during normal operation.

Soil Moisture Requirements Inputs:

Through the GUI *Figure 5.1(2).*, the user has the ability to setup the soil moisture requirements. The user has the option of selecting a specific moisture level that the system will always maintain. The user also has the option of selecting a minimum and maximum moisture level, in which case the plant will only get watered when the soil moisture goes below the minimum, and it will continue watering until the moisture has reached the maximum.

Water Level Detection & Overflow Detection

The system includes a water level detection for the water supply and can notify the user to refill the water. The system also has a water overflow detection to shut down water supply if there is an overflow of water from the pot. These levels are monitored on the GUI *Figure 5.1(5)*. The system will not allow water to be pumped if the water level is at minimum or if there is a spill detected. The system will resume normal operation once the user has addressed the issue displayed on the GUI.

Light/Temperature/Humidity Monitoring

The live values of the Ambient Light, Temperature, and Humidity are displayed on the GUI *Figure 5.1(4)*. The light value is displayed as low light, indoor light or outdoor light. Temperature is displayed in degrees Celsius and relative humidity.

6. Software

The software for this solution can be found in the following link:

https://github.com/Thishone/Automated_Plant_Watering

7. Results & Conclusions:

All requirements and additional features were achieved in this project. It is definitely possible to automate plant growing and assist consumers in providing optimal conditions for growing the plants of their choice. Supplying sufficient water to the plant is one of the crucial steps in successful plant growth, and this system was able to deliver an automated solution to this step.

8. Future Work & Recommendation

As future work and development for this solution, here are some recommendations:

(1) Plant requirement database from which the user can select the desired plant he/she is planting. This eliminates the requirement for having to setup the soil moisture levels as this will be included in the database.

(2) Providing useful feedback to user about ambient readings and whether the amount of light, temperature and humidity in order to expose the plant to optimal conditions

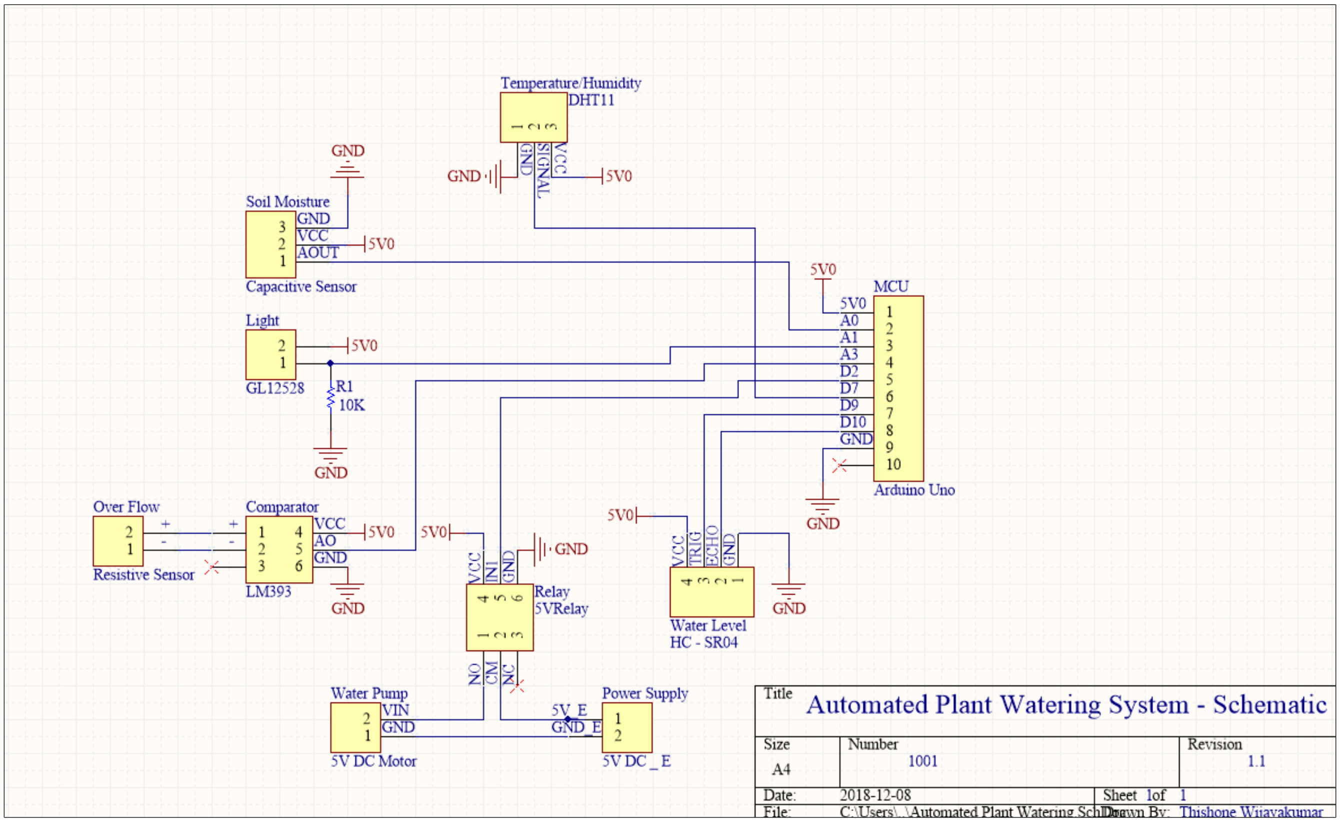
(3) Automated Light exposure for the plant based on its requirements

(4) IoT infrastructure for the ability to add this system to multiple plants within the household

9. Acknowledgements

We would like to acknowledge Robert Elder (Project Sponsor), Ralph Stacey (Project Mentor), and Mike Jarabek (ESD Program Coordinator) for their support in completing this project.

Appendix A: Schematic



Appendix B: RJ 45 Connection

For Ease of connection from Components to Arduino, and to reduce risk of water damage to MCU, an RJ 45 connector was used to connect components to Arduino. The connector descriptions are listed in this table. Note: Light Sensor was directly connected to Arduino due to availability of pins.

Pin Label	Pin Color	Description	Arduino Pin
RD	Red	5V0	5V
BK	Black	Ground	GND
OR	Orange	Soil Moisture - AOUT	A0
BL	Blue	Overflow – AO	A3
WH	White	Temp/Humidity - SIGNAL	D7
BR	Brown	Motor Control – IN1	D2
YL	Yellow	Sonar Echo	D10
GR	Green	Sonar Trigger	D9

Appendix C: References:

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