Greenie: The Smart Irrigator

Group 10

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Project Narrative Description

Motivation

Irrigated agriculture has become one of the most important sectors of the U.S. economy while being the largest consumer of consumptive water. Methods of using water smartly have been looked into because of this reason. In hopes of aiding this situation, our team has decided to design a smart irrigation system using the Internet of Things technology, or IoT.

A smart irrigation system could be of great help in managing water utilization. We have chosen to implement a more local approach with our project, giving individuals the chance to help their communities and the global population by growing herbs from the comfort of their homes.

Goals and Objectives

The goal of this project was to create an easy-to-use and portable smart irrigation system using IoT. Our product, Greenie, allows users to monitor and irrigate herbs remotely, making the gardening process hassle-free. Given that the system is relatively compact, it can be placed anywhere inside a home or an outdoor garden.

The user has access to a web application that tracks the plant's data. The application, which the user can access comfortably from anywhere, is available on any mobile device or computer through the use of a link, making our device as easy to use for any type of user, whether they are beginners, intermediate, or advanced gardeners.

Functions Outline

Hardware

Using our hardware, the user is able to acquire various information regarding:

- Soil moisture
- pH level
- Humidity and temperature from air/room
- Whether herb was watered by rain or not

Software

Using our software, the user can:

- Water their plant automatically through their mobile device or voice
- Tap on their screen to either select automatic watering or water their plants manually
- Observe herb's data on LCD

Specifications

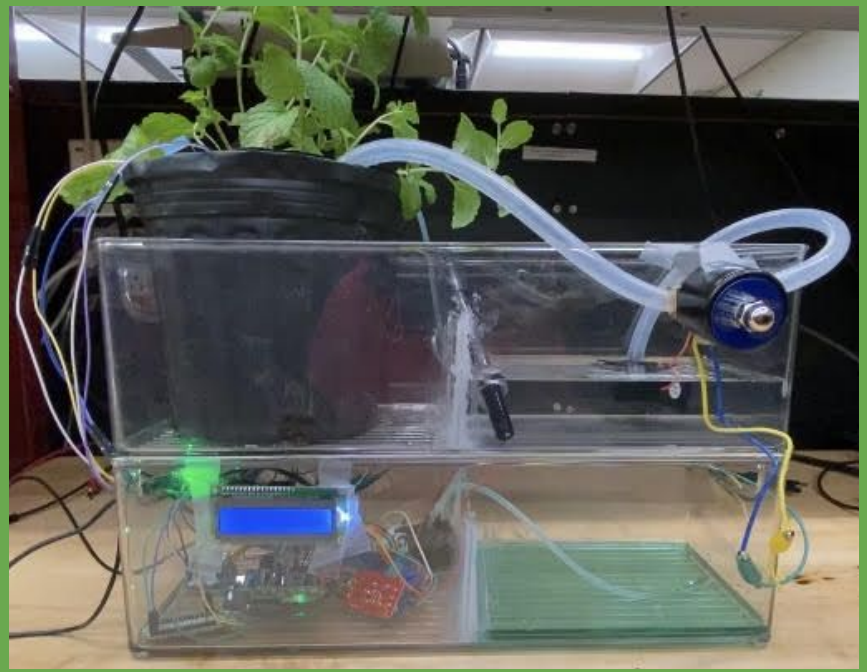
Attribute	Description
Dimension	20” x 20” x 20” (should not exceed)
Weight	15 lbs. (should not exceed)
Power Supply	Range needed for microcontroller: 7 V - 12 V Duration: At least 12 hours
Microcontroller	I/O pins: 10 (min) Operating voltage: 5 V
LCD	16 Character x 2 Line
Sensors	3 soil moisture sensors 1 rain sensor 1 humidity and temperature sensor 1 pH sensor
Sensor Measurements	1 per hour or on demand by the user

Relay Module	Voice Response Time (Alexa) <= 5 seconds
Water Source	24 fl oz water container
Water Pump	Pump head: 2.5 M / 8.2 ft (min) Flow rate: 240L/H 63.4GPH (min)
Interface	< 5 seconds response time
Plants Supported	10 herbs total 1 supported at a time
Alexa Commands	At least 3 unique commands
Communication Protocol: System	Wi-Fi
Communication Protocol: Sensors	UART SPI I2C

Design

Product Design: Front View

Greenie's design takes into consideration aesthetics as well as small-garden efficiency. Greenie consists of four different sections enclosed in two rectangular containers. These four different sections are the "Herb and Soil" and "Water" encasements, located on the top container, and the "Electronics" and "Nutrients" encasements, located on the bottom container.



Product Design: Top Compartments

The “Herb and Soil” encasement houses the user’s selected herb out of the ones supported by the software. The user can fill in the area with their selected soil type, allowing the user to personalize. All of the sensors and the outlet tubings of our water pump and nutrient pump are located in this section.

In the “Water” encasement, the water required to irrigate the herb is contained. In this compartment, the inlet/outlet water pump is located. Our pH sensor is located in this encasement as well. The solenoid valve is not submergible so it is placed outside of the compartment but still connected to the water pump tubing.

Product Design: Bottom Compartments

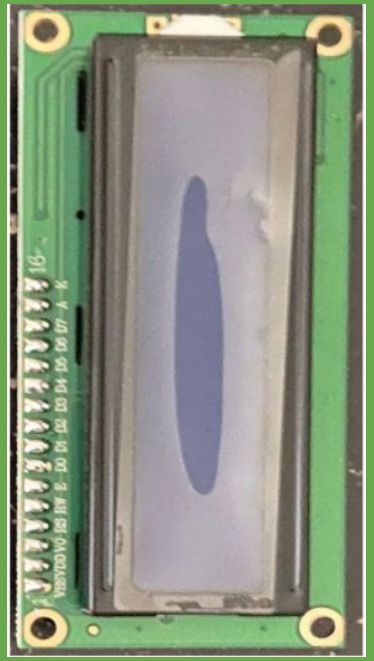
In the “Electronics” section, the parts and components required for the project to function are placed. In this compartment, the PCB, LCD, and any other electronic parts needed are located. The smart speaker is located outside, but close to the encasement so that the user can easily access this part when needed.

In the “Nutrients” compartment, the nutrient solution required by the current herb is contained. The nutrient pump is not submergible so it is placed in the “Electronics” compartment while the tubing is inside the nutrient solution. The outlet tubing leaves the compartment through open handles to reach the herb supposed to be watered above. The tubing is long enough to ensure that the nutrients reach the herb.

Parts

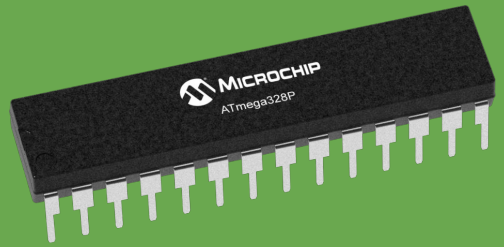
Liquid Crystal Display (LCD)

Attribute	LCD-013-420	LCD1602	0.96" OLED Module
Communication Protocol	I2C	I2C	I2C
Text Dimensions	4 x 20	2 x 16	128 x 64 OLED
Text Color	White	White	White
Address	0x27	0x27	0x3C
Cost	$6.99	$0.00 (owned)	$9.99



Microcontroller (MCU)

Attribute	Atmel ATmega328P	Texas Instruments ARM Cortex-M3	Texas Instruments MSP430
Communication Protocol	UART, SPI, I2C	SCI, SPI, I2C	UART, SPI, I2C
Memory	32 KB	256 KB	128 KB
Maximum I/O Pins	23	52	83
Operating Frequency	20 MHz	50 MHz	16 MHz
Operating Voltage	5 V	2.5 V	3.3 V



AC/DC Power Adapter

Attribute	Corporate Computer Power Supply Adapter	SmoTecQ Store Power Supply Adapter	TMEZON Power Adapter Supply
Input Voltage	110 V AC	240 V AC	240 V AC
Output Voltage	9 V DC	12 V DC	12 V DC
Current Rating	1 A	2 A	2 A
Polarity Dimensions	Positive center, negative sleeve	Positive center, negative sleeve	Positive center, negative sleeve
Connector	5.5 x 2.1 mm	5.5 x 2.1 mm	5.5 x 2.1 mm
Cost	$6.99	$11.99 for 2	$7.99

Soil Moisture Sensor

Attribute	SparkFun Soil Moisture Sensor	Adafruit STEMMA Soil Sensor	KeeYees LM393
Arduino Compatibility	Yes	Yes	Yes
Number of Prongs	2	1	2
Operating Voltage	3.3 - 5 V	3 - 5 V	3.3 - 5 V
Output Type	Analog	Analog	Analog and Digital
Cost	$5.95 for 1	$7.50 for 1	$7.99 for 5

Rain Sensor

Attribute	FC-37	FC-37	MH-RD
Manufacturer	ACROBOTIC	HiLetgo	Teyleten Robot
Output Current	15 mA	15 mA	15 mA
Operating Voltage	3 - 5 V	3 - 5 V	3.3 - 5 V
Output Type	Analog and Digital	Analog and Digital	Analog and Digital
Cost	$8.99 for 1	$5.99 for 3	$5.88 for 3

Humidity and Temperature Sensor

Attribute	RHT03	DHT11	AM2302
Range	0 - 100% RH 40 - 80 °C	20 - 80% RH 0 - 50 °C	0 - 100% RH -40 - 80 °C
Maximum Current	1 - 1.5 mA	2.5 mA	2.5 mA
Operating Voltage	3.3 - 6 V	3 - 5 V	3 - 5 V
Measurement Accuracy	± 2% RH ± 0.5 °C	± 5% RH ± 2 °C	± 2% RH ± 0.5 °C
Cost	$12.95 for 1	$0.00 (owned)	$18.49 for 4

pH Sensor

Attribute	DONGKER pH Sensor Module	GAOHOU PH0-14 Sensor Module	BOOTOP PH0-14 Sensor Module
Range	0 - 14 pH 0 - 60 °C	0 - 14 pH 0 - 80 °C	0 - 14 pH 0 - 80 °C
Working Current	5 - 10 mA	5 - 10 mA	5 - 10 mA
Operating Voltage	5 V	5 V	5 V
Zero Point	7 ± 0.01 pH	7 ± 0.25 pH	7 ± 0.25 pH
Cost	$36.99 for 1	$35.59 for 1	$35.19 for 1

Relay Module

Attribute	HiLetgo 5V	WINGONEER KY-019 5V	KeeYees 5V Relay Module
Operating Voltage	5 V	5 V	5 V
Maximum AC	AC 250 V / 10 A	AC 250 V / 10 A	AC 250 V / 10 A
Maximum DC	DC 30 V / 10 A	DC 30 V / 10 A	DC 30 V / 10 A
Cost	$5.98 for 2	$8.49 for 5	$9.99 for 5

Water Pump

Attribute	LEDGLE	Mavel Star	MOUNTAIN_ARK
Rated Voltage	DC 12 V	DC 12 V	DC 12 V
Rated Power	3.6 W	4.8 W	4.5 W
Lift	3 M / 9.8 ft	3 M / 9.8 ft	3 M / 9.8 ft
Flow Rate	240L/H 63.4GPH	240L/H 63.4GPH	240L/H 63.4GPH
Current	300 mA	350 mA	400 mA
Cost	$8.99	$12.99	$10.99

Smart Speaker

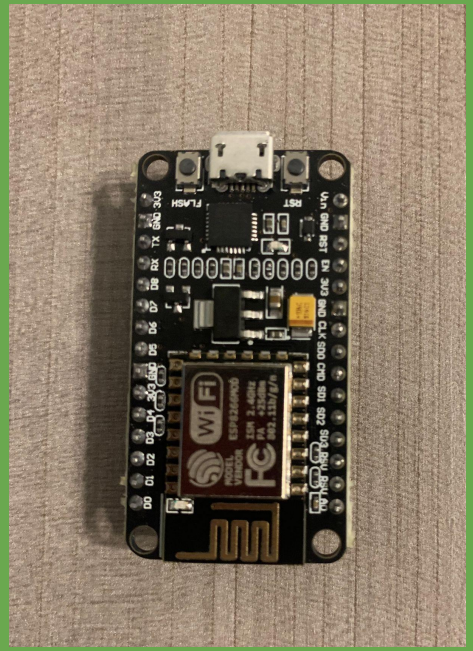
Attribute	Apple HomePod Mini	Amazon Echo Dot	Google Nest Mini
Released In	2020	2020	2019
Voice Assistance	Siri	Alexa	Google Assistant
Microphones	4	4	3
Dimensions	97.9 x 84.3 mm	100 x 100 x 89 mm	98 x 42 mm
Weight	0.76 lbs (345 g)	0.75 lbs (341.3 g)	0.4 lbs (183 g)
Cost	$99.00	$0.00 (owned)	$49.00

Solenoid Valve

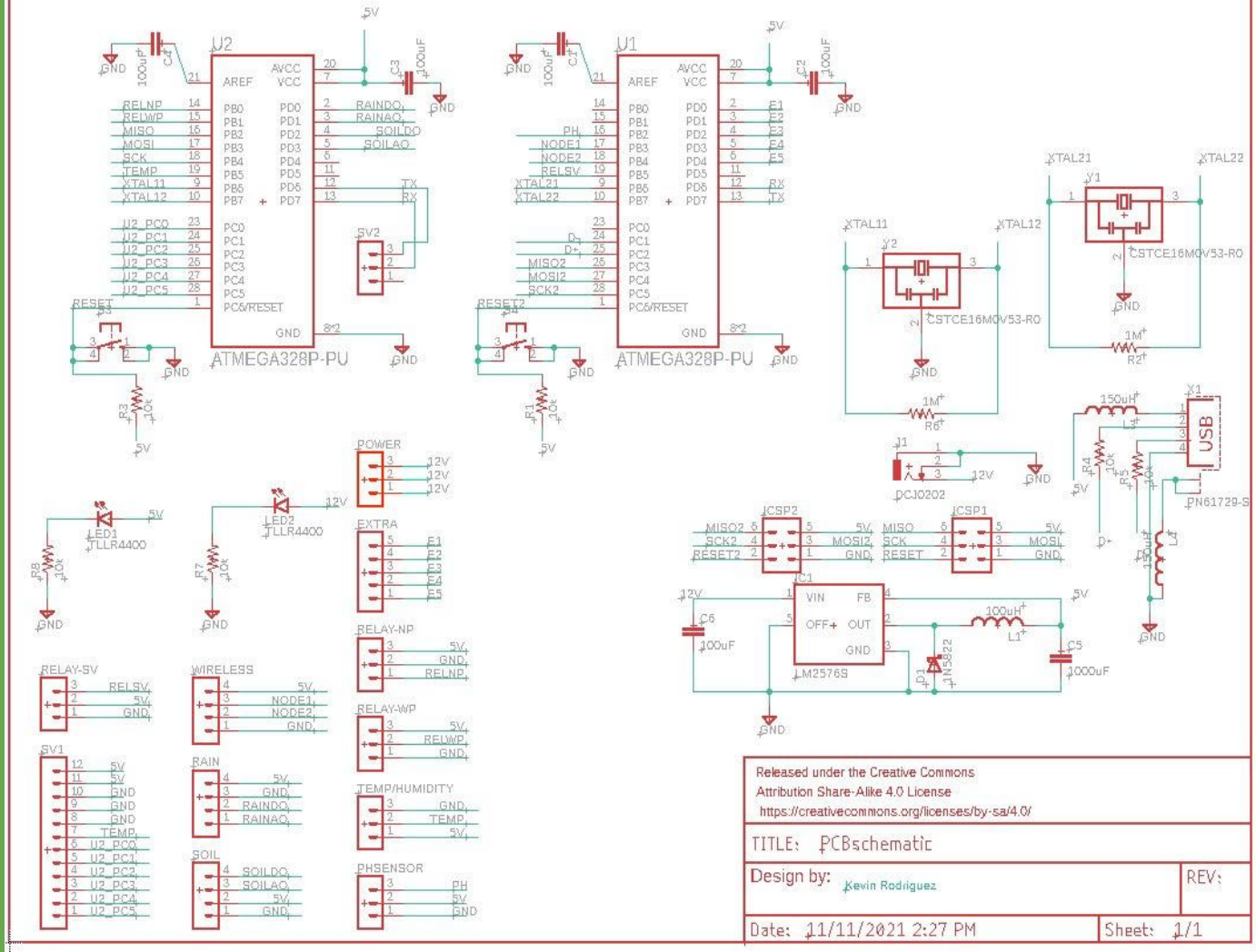
Attribute	Digiten	Kako	NPT	HFS
Rated Voltage	12V DC	110V AC	12V DC	12V DC
Working Temp	0-70 °C	23-176 °F	-5 - 85 °C	23 - 176 °F
Pressure	0.02-0.08 Mpa	0 - 145 Psi	15 - 70 Psi	0 - 145 Psi
Material	Plastic	Brass	Copper	Brass
Size	¼ inch	1 inch	¼ inch	¼ inch
Cost	$7.69	$32.99	$15.69	$13.99

Wi-Fi Module

Attribute	ESP8266 NodeMCU	ESP32	Bolt IOT Module
Wi-Fi	802.11 b/g/n	802.11 b/g/n	802.11 b/g/n
Operating Voltage	3.3 V	3.3 V	3.3 V
Clock Speed	80 MHz	160 MHz	80 MHz
Bluetooth	X	Bluetooth 4.2 and BLE	X
Cost	$6.49	$21.88 for 3	$150.00



Printed Circuit Board (PCB)


U2
U1
ATMEGA328P-PU
ATMEGA328P-PU
XTAL21
XTAL22
XTAL11
XTAL12
CSTCE16M0V53-R0
CSTCE16M0V53-R0
USB
PN61729-S
PCJ0202
ICSP2
ICSP1
IC1
M2576S
1N5822
POWER
EXTRA
RELAY-NP
RELAY-WP
TEMP/HUMIDITY
PHSENSOR
RELAY-SV
WIRELESS
RAIN
SOIL
SV1
SV2
LED1
LED2
TLLR4400
TLLR4400
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TITLE: PCBschematic
Design by: Kevin Rodriguez
REV:
Date: 11/11/2021 2:27 PM
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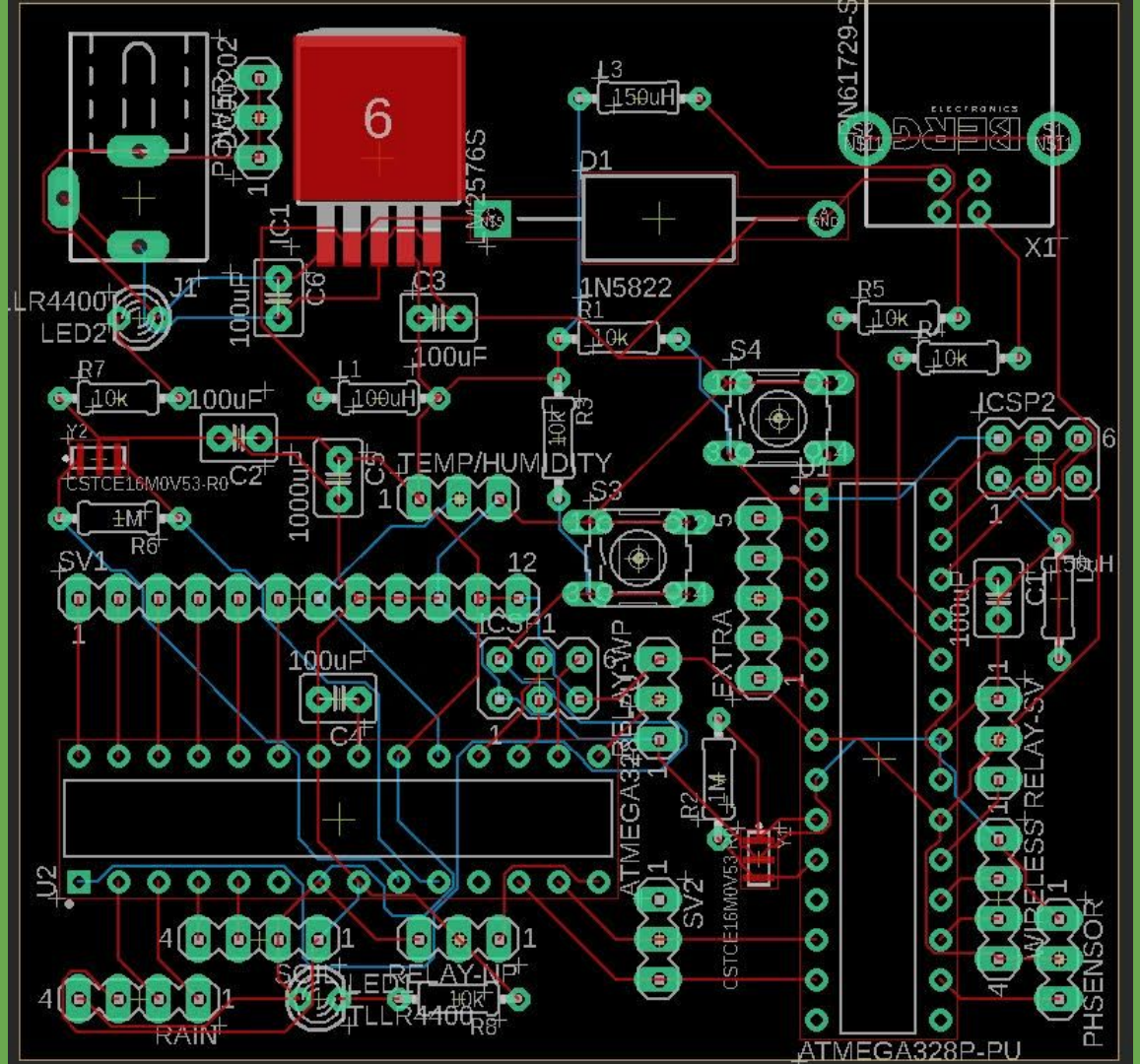

6
LM2576S
L3
150uH
D1
1N5822
IN61729-S
X1
POWER JACK
JC1
C6
100uF
C3
100uF
J1
LED2
TLLR4400
R7
10k
100uF
L1
100uH
R1
10k
R3
10R
S4
R5
10k
R4
10k
JCSP2
C2
100uF
CSTCE16M0V53-R0
C5
1000uF
JTEMP/HUMIDITY
S3
R6
1M
SV1
JCSP1
C4
100uF
RELAY-SVP
EXTRA
R2
1M
SV2
ATMEGA328P-PU
C1
100uF
L2
150uH
WIRELESS RELAY-SV
PHSENSOR
U2
SOIL
RAIN
LED1
TLLR4400
RELAY-NP
R8
10k

Software

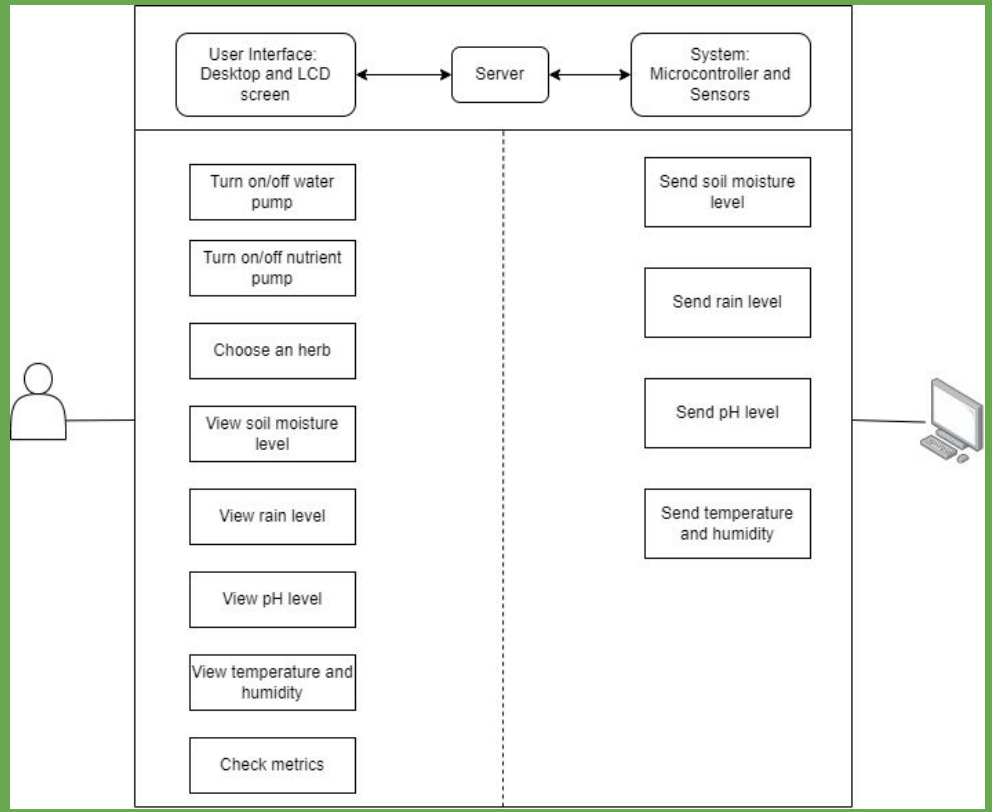
Software Overview

Back End

- Continually collecting data from our sensors and making it available for our web server provider
- Data will be stored and pulled from Firebase Realtime Database

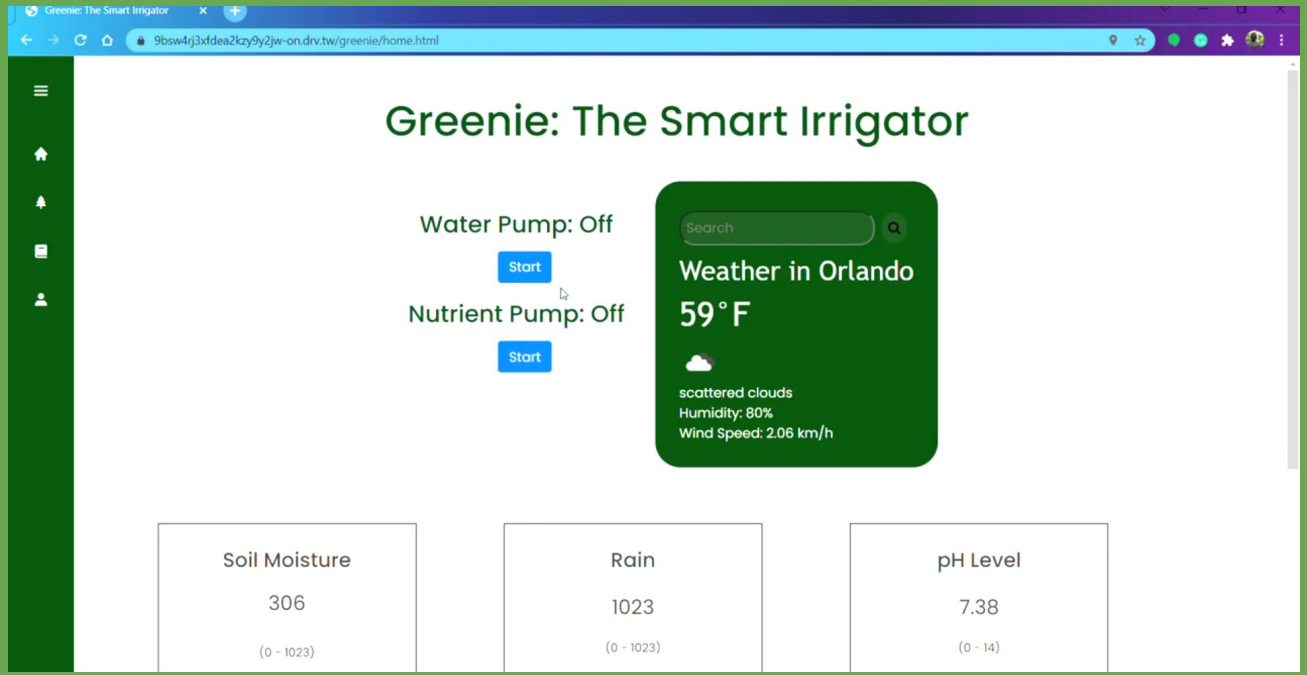
Front End

- User can remotely control the system
- View data on demand
- Receive notifications



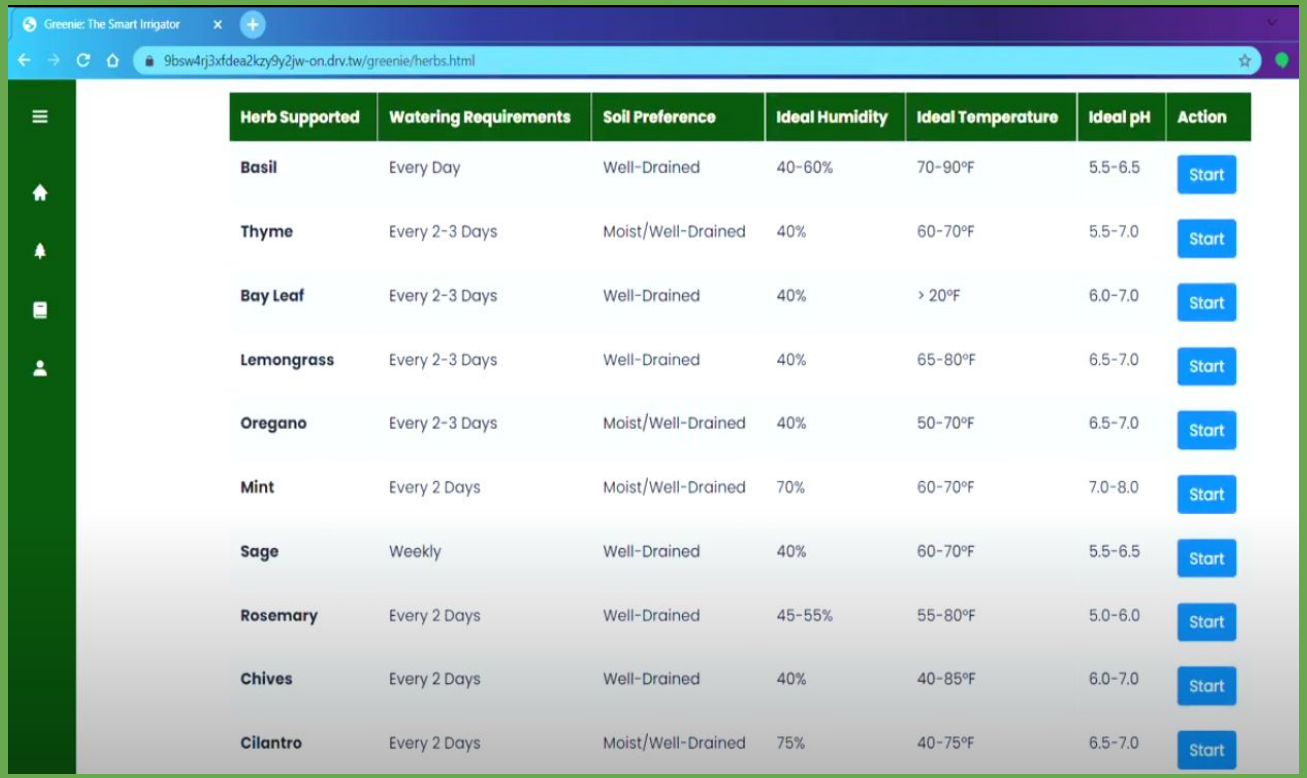
Web Application: Home

- The home page displays the sensors current readings
- There is a button for users to manually turn on the water pump
- Weather data is integrated so user knows if rain can water herb if placed outside



Web Application: Herb Selection

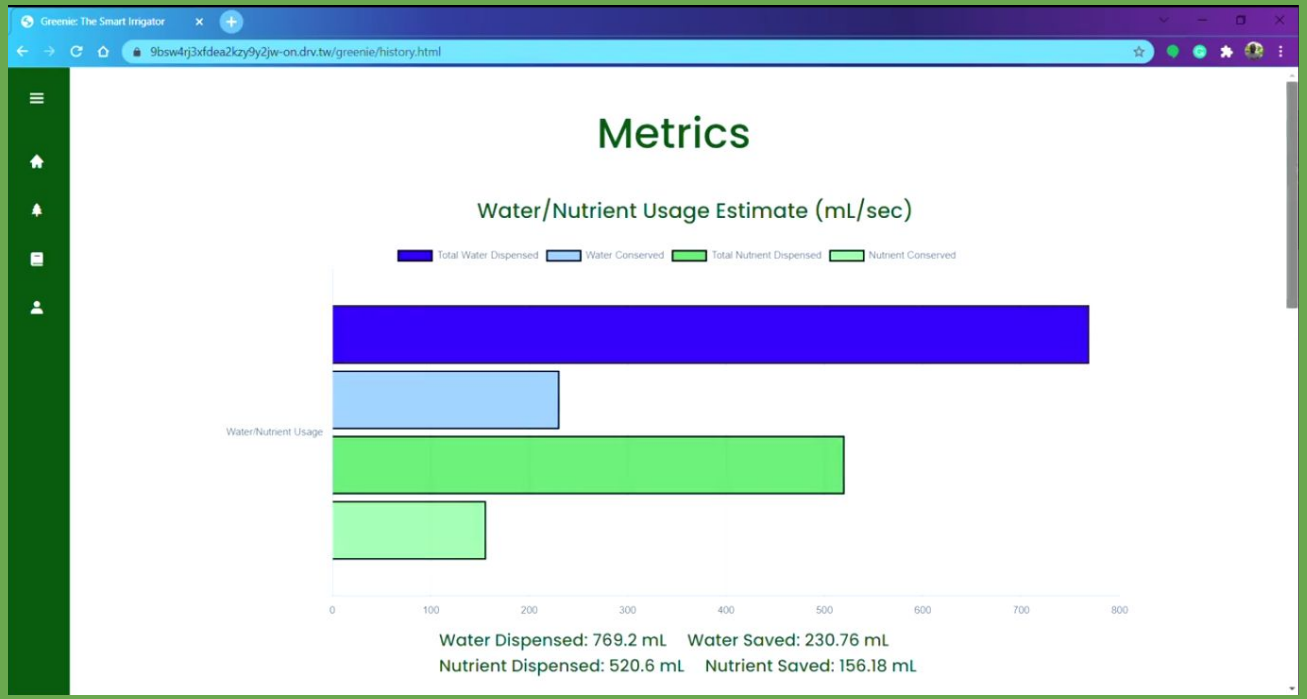
- 10 herbs supported in total
- Information on each herb and its watering schedule is provided
- Selecting an herb begins its automatic watering schedule
- Soil preference, ideal humidity, temperature, and pH are given



Herb Supported	Watering Requirements	Soil Preference	Ideal Humidity	Ideal Temperature	Ideal pH	Action
Basil	Every Day	Well-Drained	40-60%	70-90°F	5.5-6.5	Start
Thyme	Every 2-3 Days	Moist/Well-Drained	40%	60-70°F	5.5-7.0	Start
Bay Leaf	Every 2-3 Days	Well-Drained	40%	> 20°F	6.0-7.0	Start
Lemongrass	Every 2-3 Days	Well-Drained	40%	65-80°F	6.5-7.0	Start
Oregano	Every 2-3 Days	Moist/Well-Drained	40%	50-70°F	6.5-7.0	Start
Mint	Every 2 Days	Moist/Well-Drained	70%	60-70°F	7.0-8.0	Start
Sage	Weekly	Well-Drained	40%	60-70°F	5.5-6.5	Start
Rosemary	Every 2 Days	Well-Drained	45-55%	55-80°F	5.0-6.0	Start
Chives	Every 2 Days	Well-Drained	40%	40-85°F	6.0-7.0	Start
Cilantro	Every 2 Days	Moist/Well-Drained	75%	40-75°F	6.5-7.0	Start

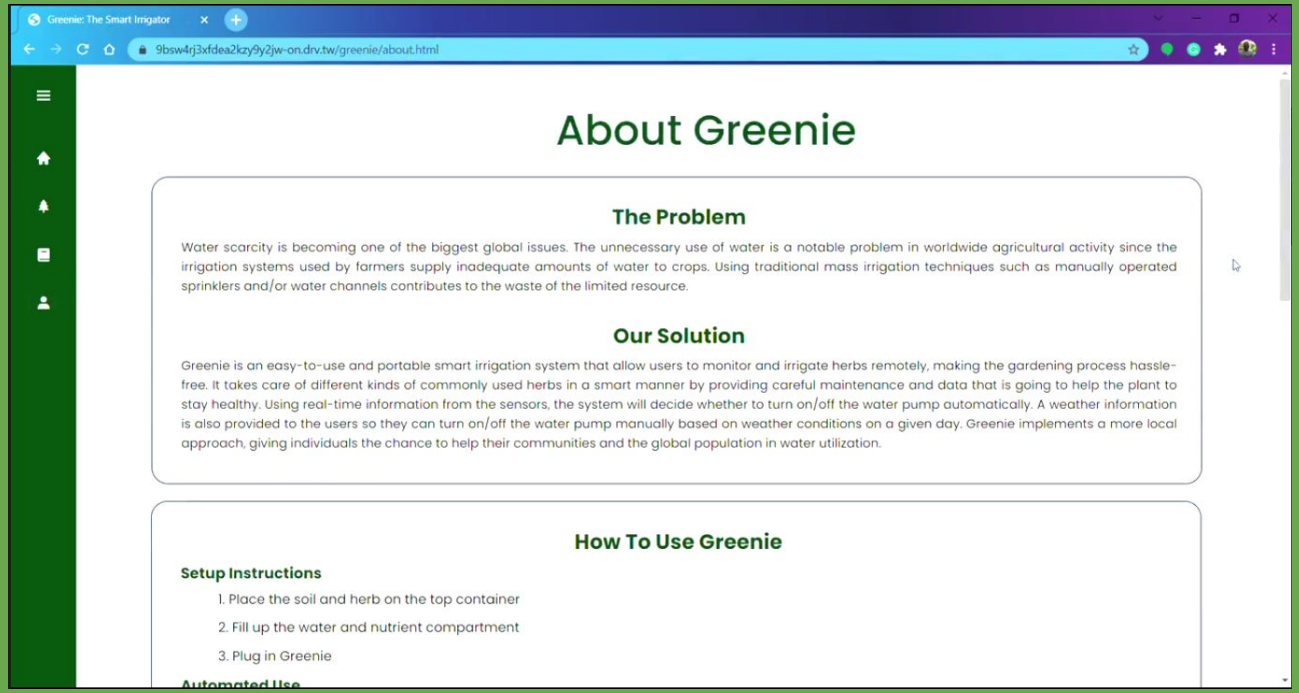
Web Application: Metrics

- “Metrics” page with sections including “Water/Nutrient Usage Estimate (mL/sec),” “Average Sensor Reading Estimate (5 Automated Readings),” and “Manual/Automated Pump Usage Estimate (%).”



Web Application: About

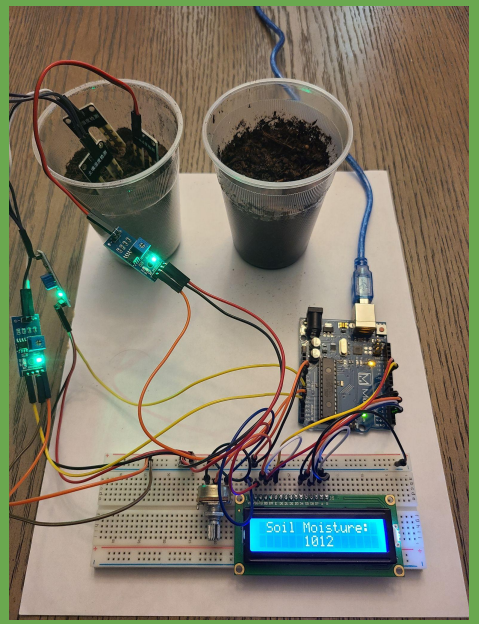
- Includes information on Greenie's motivation and goals
- Includes "How to Use Greenie" section with information on setup instructions, automated use, manual use, weather integration, and recognized Alexa Commands
- Also includes "Frequently Asked Questions" section

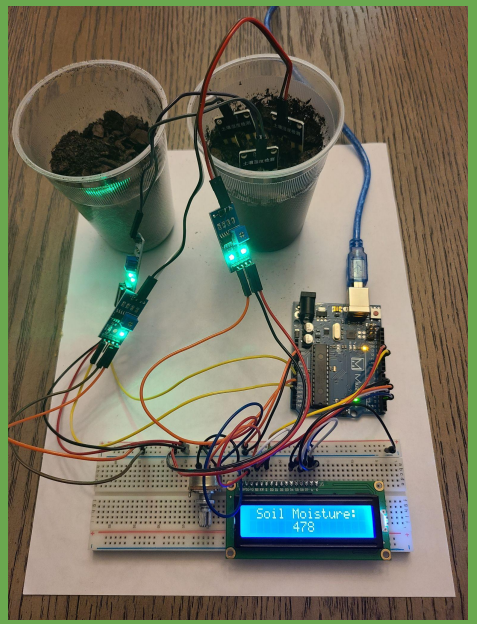


Prototyping

Prototyping: Soil Moisture Sensor

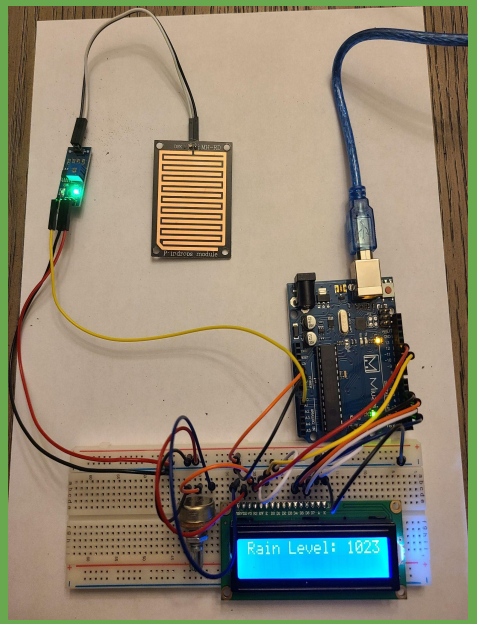
- 1 sensor was used to read the soil moisture of the plant
  - Wet Soil: 0 - 350
  - Well-Drained Soil: 351 - 650
  - Dry Soil: 651 - 1023
- Test Results
  - Dry soil ≈ 1012
  - Soil with water ≈ 478

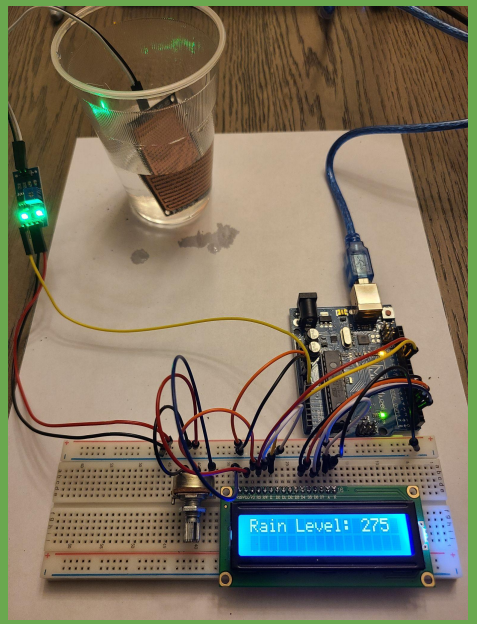




Prototyping: Rain Sensor

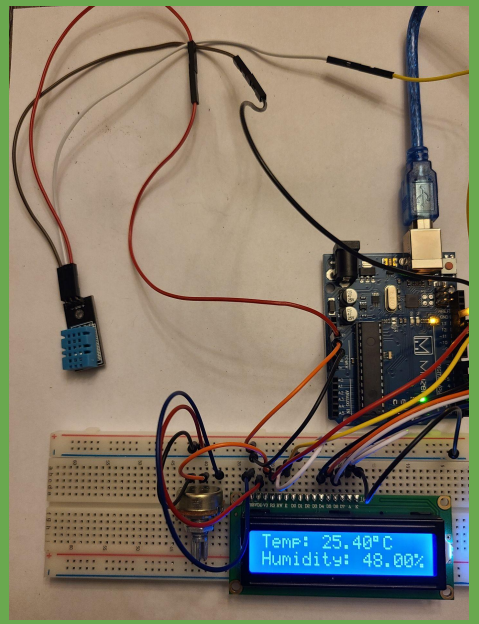
- 1 sensor was used to monitor the amount of rainfall
  - Raining: 0 - 400
  - Not Raining: 401 - 1023
- Test Results
  - Completely dry ≈ 1023
  - Sprinkle of water ≈ 471
  - Soaked in water ≈ 275

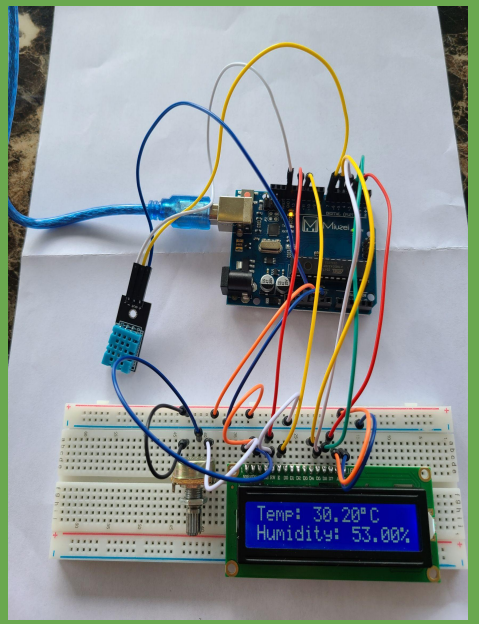




Prototyping: Humidity and Temperature Sensor

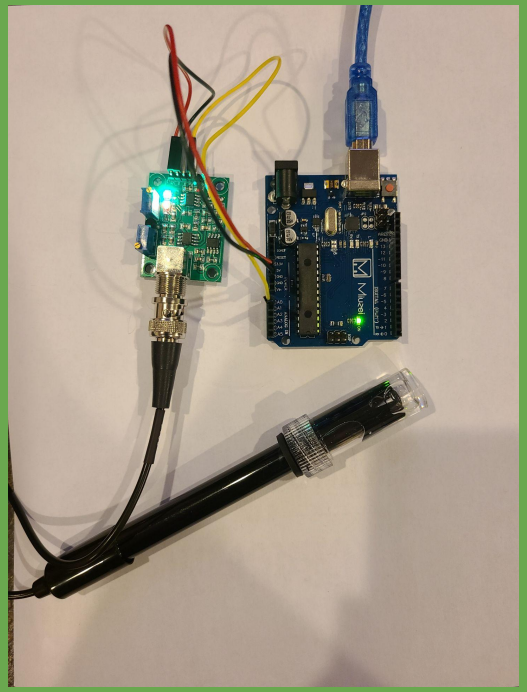
- Reads data from the environment to maintain plant's health
- Current humidity and temperature was compared to the plant's ideal humidity and temperature
- Test Results
  - (Indoor) Temp = 25.4 ℃ (≈ 77.72 °F)
  - (Indoor) Humidity = 48 %
  - (Outdoor) Temp = 30.2 ℃ (≈ 86.36 °F)
  - (Outdoor) Humidity = 53 %

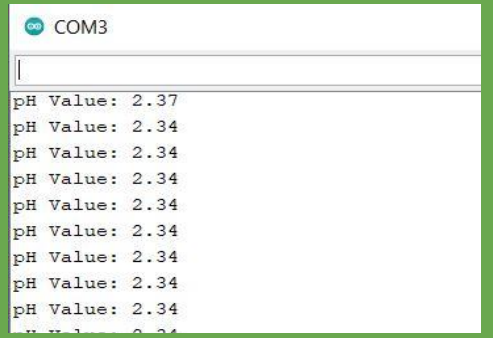




Prototyping: pH Sensor

- Measures the pH level of the plant's soil to maintain plant's overall health
- Current pH level was compared to the pH scale
- Test Results
  - Tap Water ≈ 7.13
  - Vinegar ≈ 2.34





Administrative Content

Budget and Financing Projections

- Estimated costs
- Self-funded by the group
- Other components are owned by the members
- Goal: $500

Item	Price	Quantity	Total
LCD1602 Module (already owned)	$0.00	1	$0.00
Microcontroller - Atmega328P (already owned)	$0.00	1	$0.00
Power Supply - Portable Battery	$25.00	1	$25.00
Soil Sensor	$10.00	3	$10.00
Rain Sensor	$10.00	1	$10.00
Temperature and Humidity Sensor - DHT-11 (already owned)	$0.00	1	$0.00
pH Sensor	$40.00	1	$40.00
Piezoelectric Sensor	$10.00	1	$10.00
Relay Module	$10.00	1	$10.00
Water Pump	$15.00	1	$15.00
Wi-Fi Module	$15.00	1	$15.00
Tester Herbs	$5.00	3	$15.00
Wires (already owned)	$0.00	20	$0.00
Breadboard (already owned)	$0.00	1	$0.00
Voltage Regulator 12V	$1.50	1	$1.50
Voltage Regulator 5V	$0.95	1	$0.95
Final Total = $152.45			

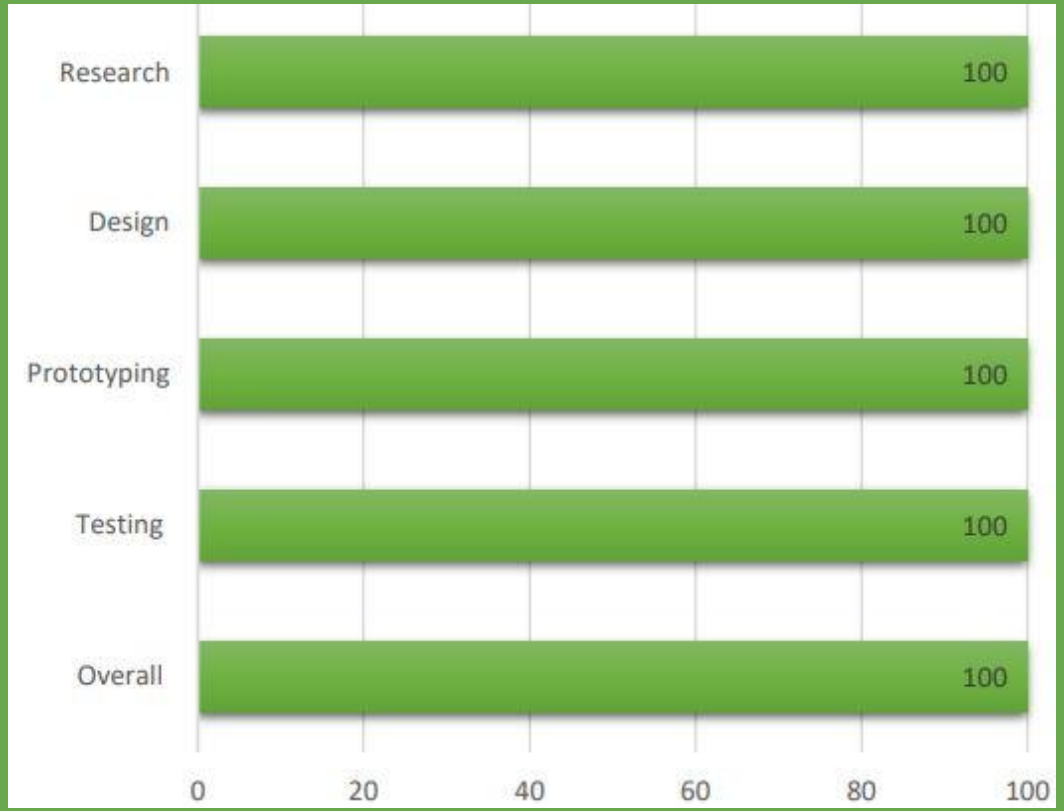
Final Budget and Financing

Number	Item	Cost
1	ESP8266 Development Board (3)	$ 6.49
2	Atmega 328P	$ -
3	LCD1602	$ -
4	Soil Moisture Sensor	$ 7.99
5	Rain Sensor	$ 5.88
6	Temperature and Humidity Sensor	$ -
7	Solar Power Bank	$ 28.99
8	Voltage Regulator Kit	$ 13.99
9	Silicone Tubing	$ 12.99
10	Water Pump	$ 8.99
11	5V Relay Module (2)	$ 5.98
12	PH0-14 Sensor Module	$ 35.59
13	3m Silicone Tube	$ 7.88
14	12V DC Dosing Pump	$ 10.98
15	5V One Channel Relay Module	$ 6.19
16	ESP8266 NodeMCU (2)	$ 12.98
17	Container	$ 24.99
18	Nutrient Solution	$ 6.89
19	Acrylic Sheet	$ 7.00
20	PCB	$ 35.51
21	PCB parts	$ 39.18
	TOTAL	**$ 278.49**

Work Distribution

Task	Primary	Secondary
Design	Angelica	None
Sensors	Angelica	Patricia
Power Supply	Kevin	Angelica
PCB	Kevin	None
Database	Elliott	None
WiFi Communication	Elliott	None
Hardware to Software	Patricia	Elliott
Web Application	Patricia	Elliott

Work Progress



Final Comments

Difficulties/Challenges

- Atmega2560 was desired but was out of stock
  - Two Atmega328Ps were chosen instead
- PCB had two iterations but LCD did not work as desired
- Implementing ideas planned in SD1 such as
  - MERN stack
  - Weather prediction included in weather integration
  - External battery supply in case of power outage

Future Upgrades

- Minimize space needed by components to optimize system's size
- Potential to add more than one herb to be supported at a time
- Incorporate the following
  - Automatic pH balancing system
  - Weather prediction
  - External battery supply