Project Eden

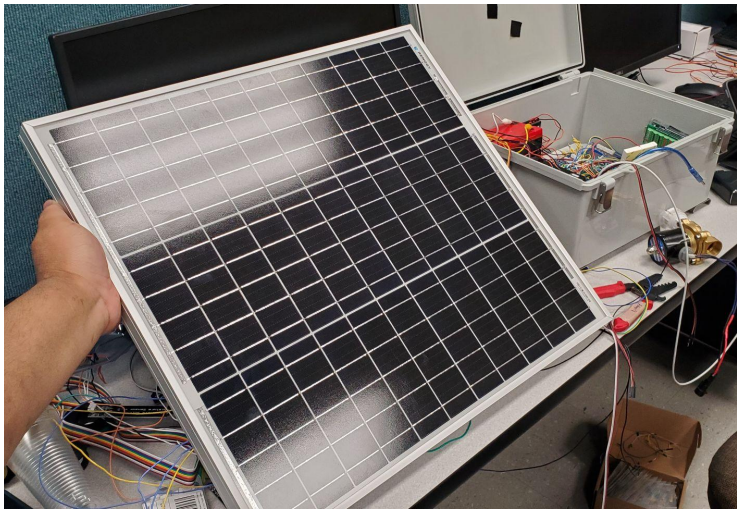
Automatic Smart Irrigation of Fullerton Arboretum’s Nursery

Introduction

- The Arboretum staff spend up to 4 hours watering plants at the nursery
- To reduce or eliminate the workload, we plan to create a smart irrigation system with collaboration with Mechanical Engineers

Design Requirements

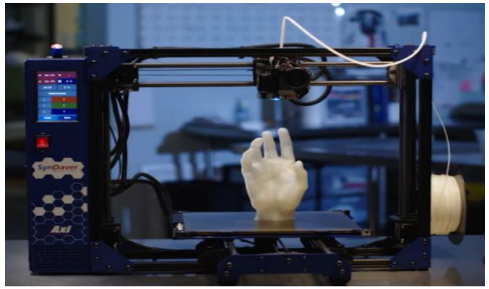
- Resistance to outdoor elements, including animals: **Electrical box**
- Self-sufficient: **Solar power**
- Curator initially needs low number of sprinklers (5) but also wants ability to expand: **Modular design**



Researched Potential Designs

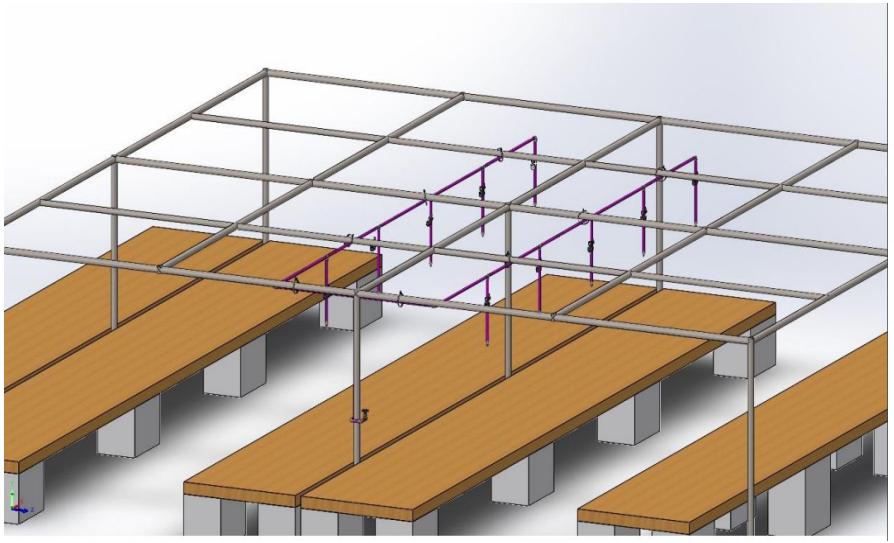
- Discussed Potential Designs with ME team and Arboretum Staff

2-D Mapping

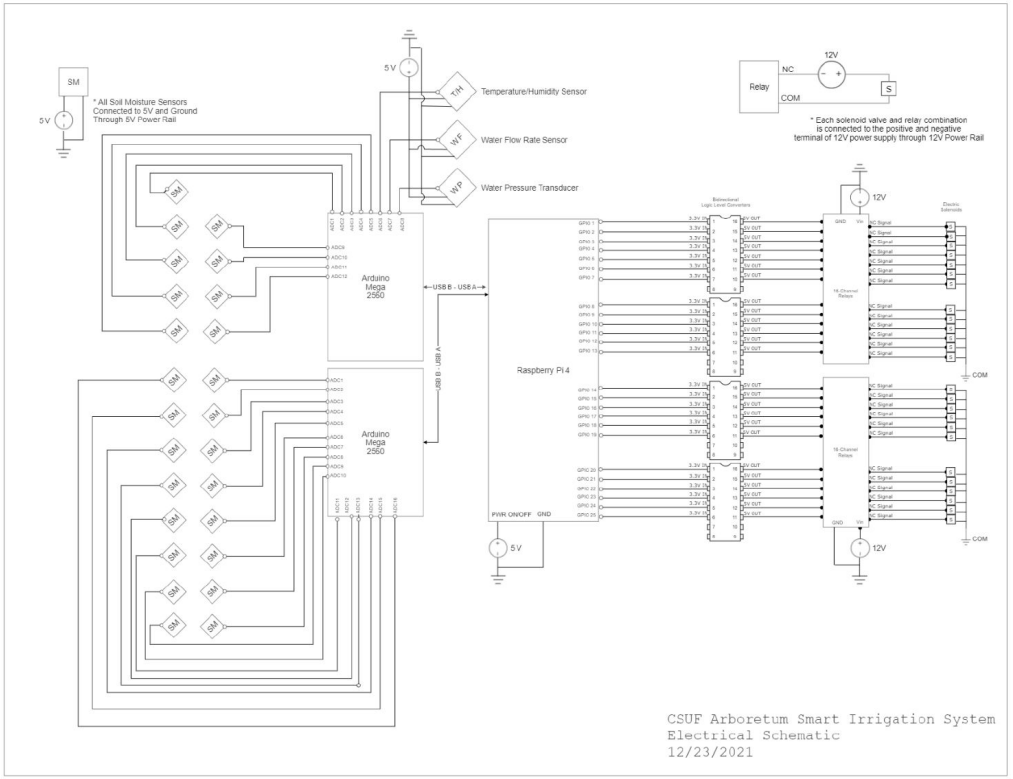


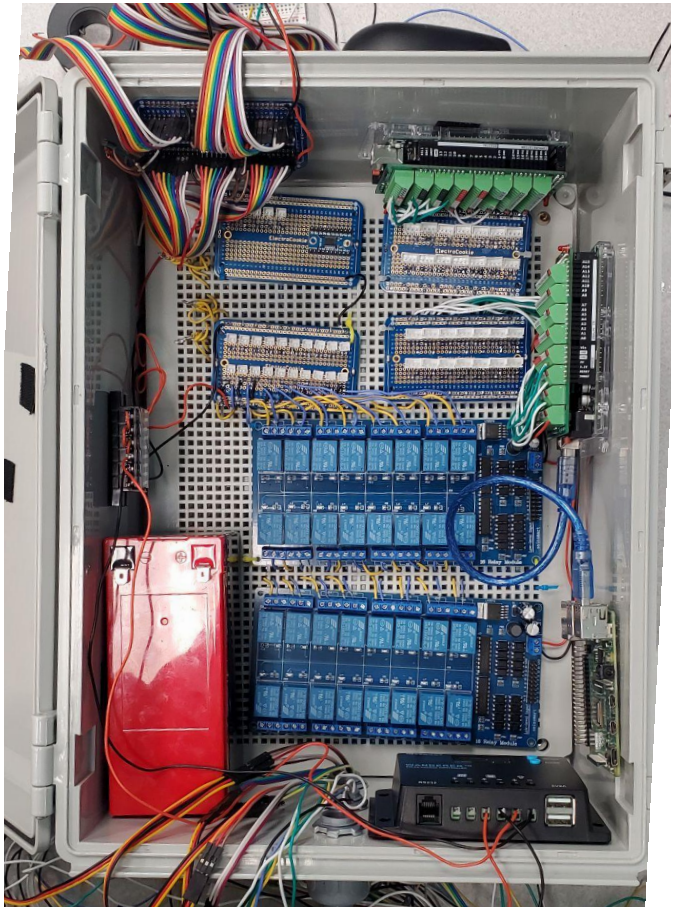
Drip Irrigation

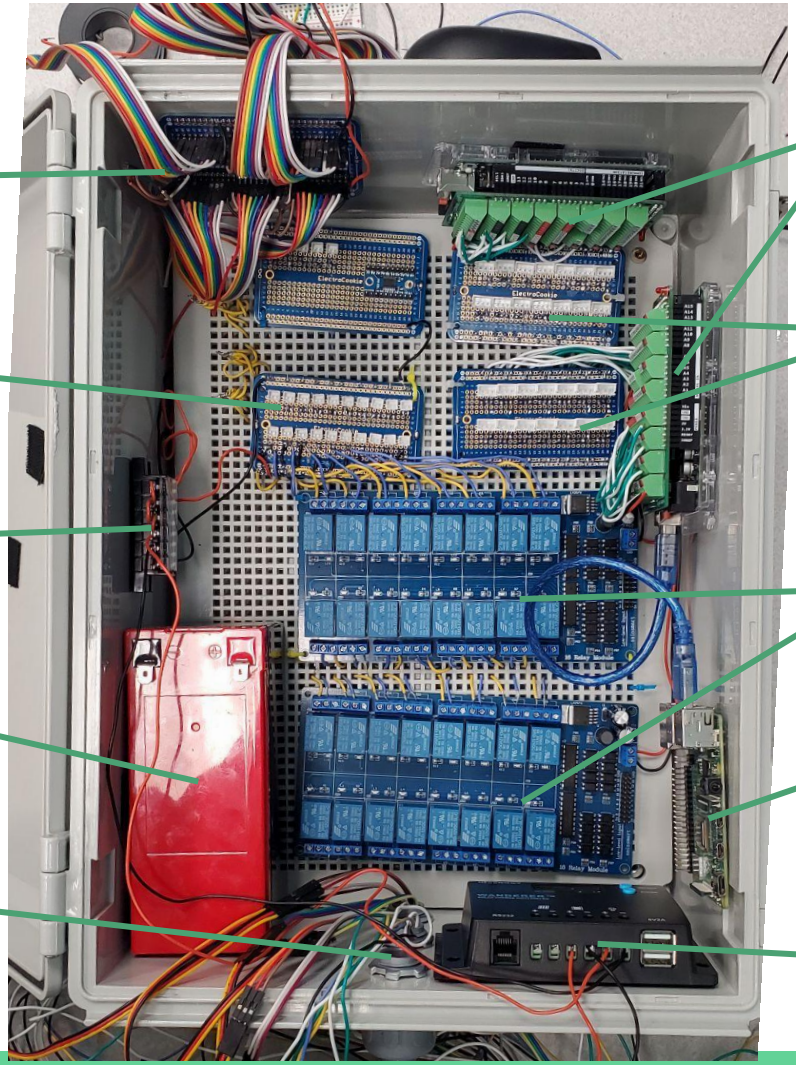
Mechanical Engineering Design



Hardware Design







Logic Level Converter Protoboard

Solenoid Plug-and-Play Protoboard

6 Channel Power Rail

12V Battery

3 Watertight Entry Points for Wiring

Arduino Mega 2560

Sensor Plug-and-Play Protoboard

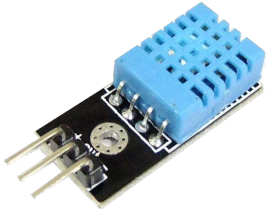
16-Channel Relay with 12V-5V Step-down Voltage Regulator

Raspberry Pi 4 B+

Solar Charge Controller

Sensors and Solenoids

Temperature/Humidity Sensor (DHT11)



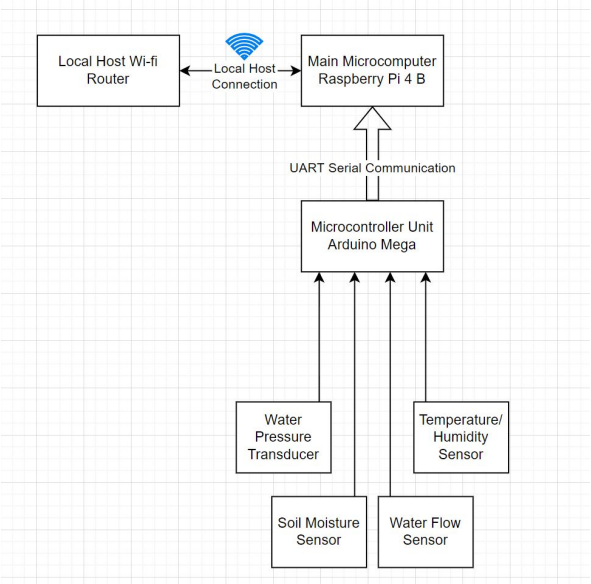
Capacitive Soil Moisture Sensor

Pressure Transducer

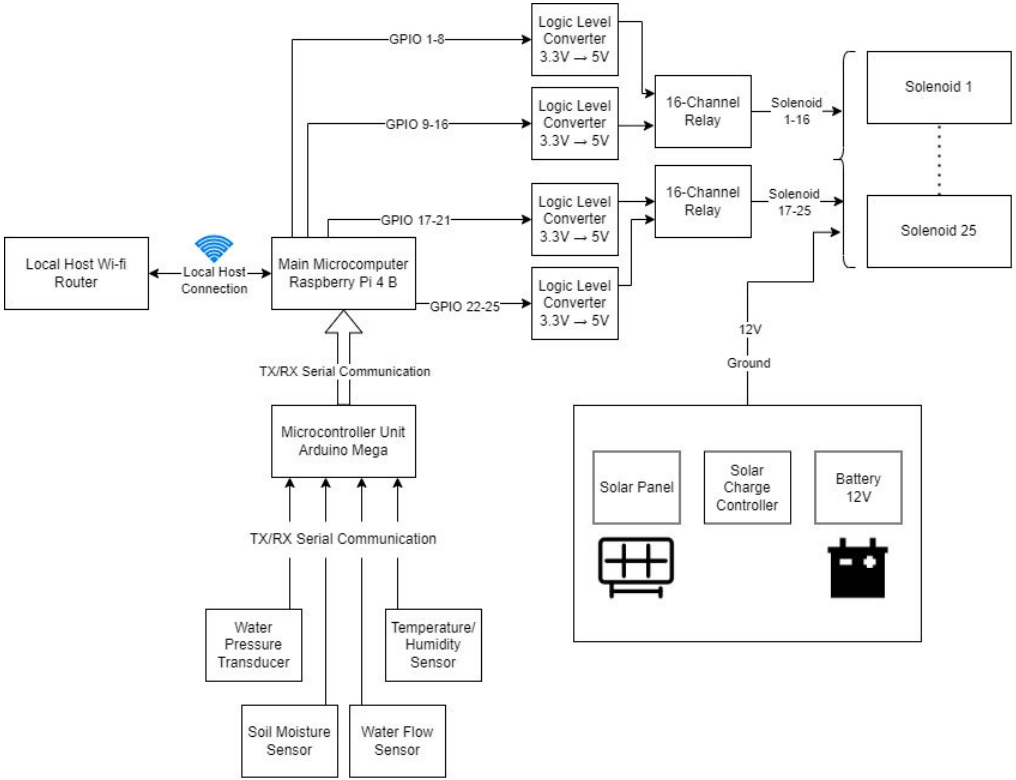
Water Flow Sensor

Sensors Integration

- Updating sensor integration code
- **1st Arduino:** Set to take a temperature/humidity, a water pressure, a water usage, and 13 soil moisture sensors and output string value to send to Raspberry Pi
    - Sensor Integration IP
- **2nd Arduino:** Set to take 16 soil moisture sensors and outputs string value to send to Raspberry Pi
- **Raspberry Pi:** Set to display sensor information on the website
    - Needs to parse string information and log corresponding data

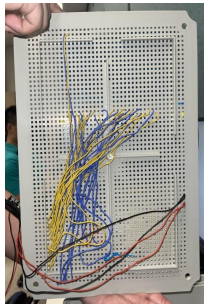


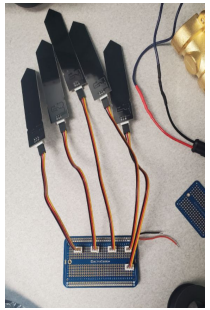
Block Diagram



Modularity Design

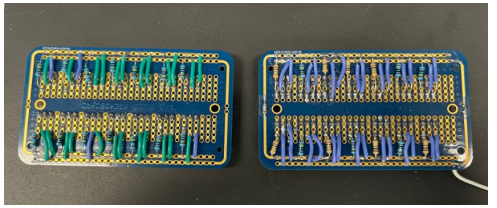
- Solenoid and Sensor Sockets
- Modular design of different custom perf boards for set of components
  - Up to 25 Solenoid I/O sockets
  - Up to 25 Sensor I/O sockets
- External Pull Down Resistors
  - Pulls all sensor values down to 0 when not plugged in using 1M ohms resistors
- Soldered wiring, JST connectors, and Waterproof connectors

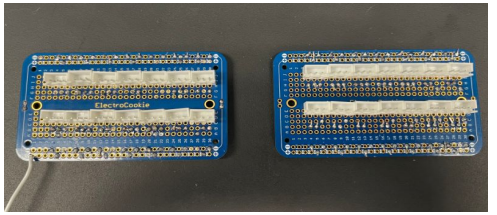


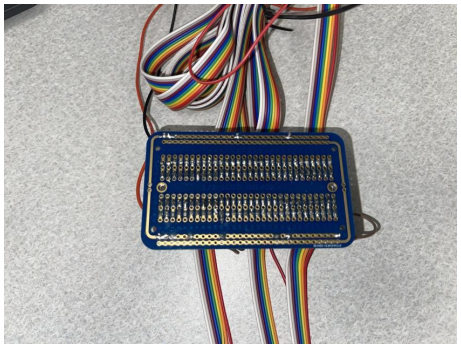


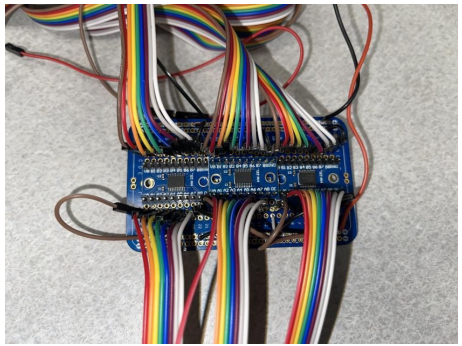
Soldering

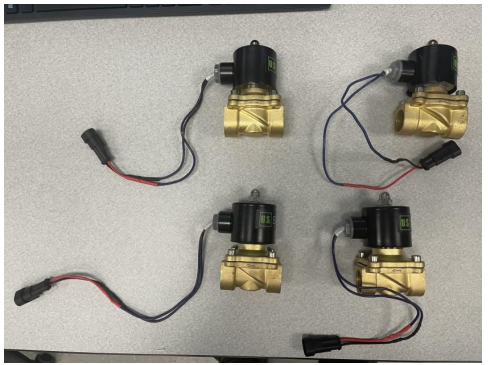
- Over 500+ soldering connections
- Attached shrink tubing to exposed wiring



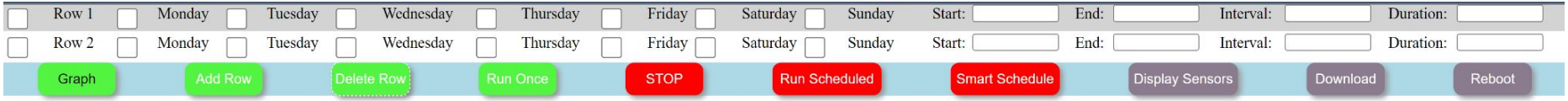






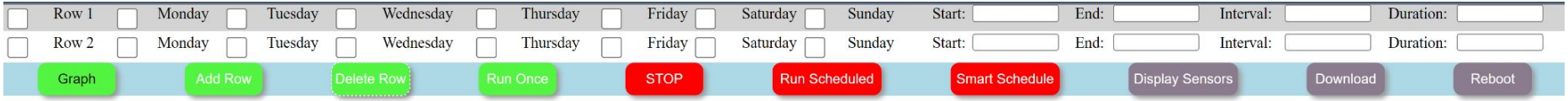


UI Design



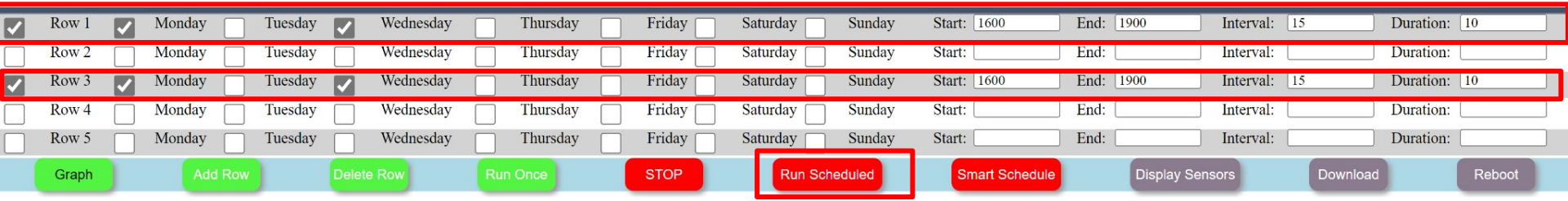
- The website continues the theme of modularity
- Any number of rows up to 25 supported

UI Functions



- Option for scheduled or single watering
- User input and sensor values are logged in CSV files
- Values are displayed in graph and stored on RPi for downloading

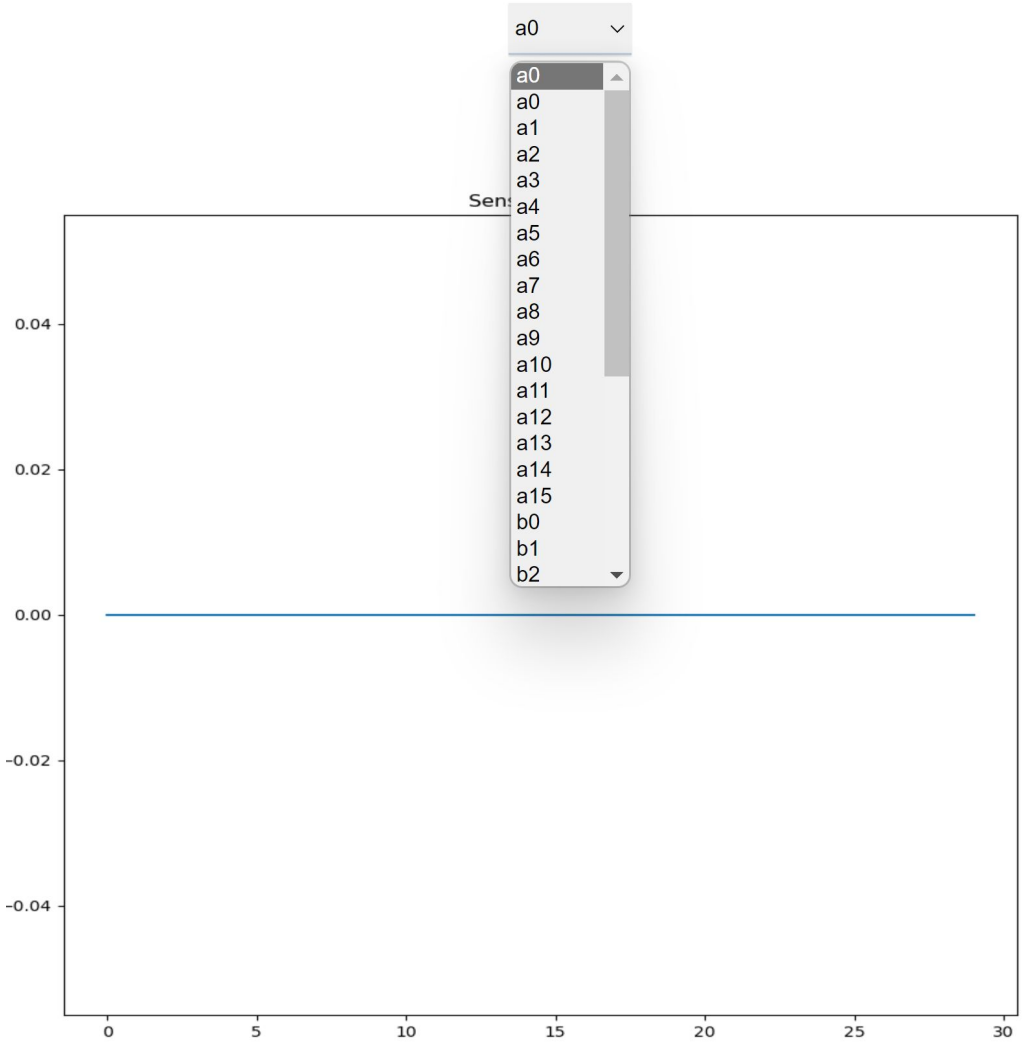
UI Example



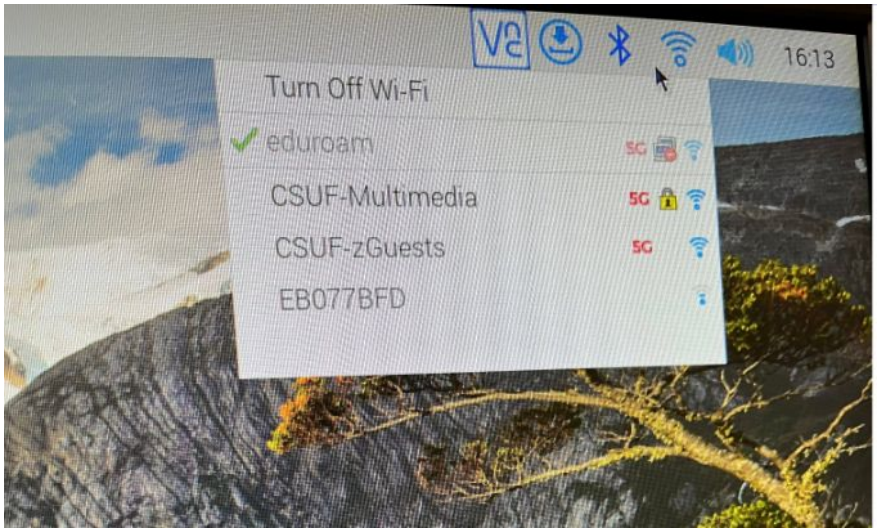
Example request from the Curator: “Water the plants every 15 minutes from 4pm-7pm every Monday and Wednesday for 10 seconds”

```
DATE: ,S2022-04-29,TIME: ,17:07:48

Row No. 1
Enabled?,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday,Start,End,Interval,Duration
True,False,False,False,False,False,False,False,1111,2359,1,12
-----------------------------------------------------
Row No. 2
Enabled?,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday,Start,End,Interval,Duration
False,False,False,False,False,False,False,False,,,,
-----------------------------------------------------
Row No. 3
Enabled?,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday,Start,End,Interval,Duration
False,False,False,False,False,False,False,False,,,,
-----------------------------------------------------
Row No. 4
Enabled?,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday,Start,End,Interval,Duration
False,False,False,False,False,False,False,False,,,,
-----------------------------------------------------
Row No. 5
Enabled?,Monday,Tuesday,Wednesday,Thursday,Friday,Saturday,Sunday,Start,End,Interval,Duration
False,False,False,False,False,False,False,False,,,,
-----------------------------------------------------
Pin Number,Sensor Reading
a0,0
a0,0
a1,0
a2,331
a3,332
a4,345
a5,331
a6,331
a7,327
a8,367
a9,347
a10,347
a11,338
a12,353
a13,360
a14,341
```


a0
a0
a0
a1
a2
a3
a4
a5
a6
a7
a8
a9
a10
a11
a12
a13
a14
a15
b0
b1
b2
0.04
0.02
0.00
-0.02
-0.04
0
5
10
15
20
25
30

UI Hosting

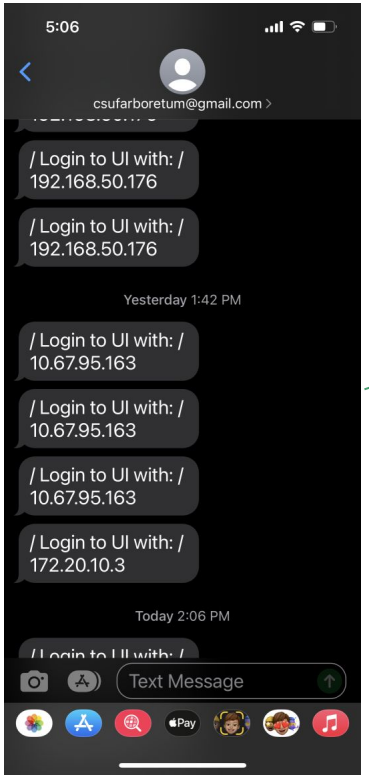


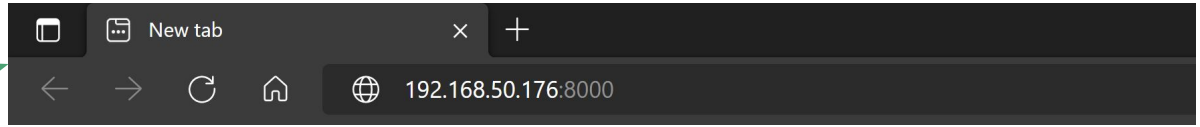
Pros:

- local network
- Internet access
- Built in security

Cons:

- User must be in the area
- Possible downtimes


5:06
csufarboretum@gmail.com
/ Login to UI with: / 192.168.50.176
/ Login to UI with: / 192.168.50.176
Yesterday 1:42 PM
/ Login to UI with: / 10.67.95.163
/ Login to UI with: / 10.67.95.163
/ Login to UI with: / 10.67.95.163
/ Login to UI with: / 172.20.10.3
Today 2:06 PM
Text Message

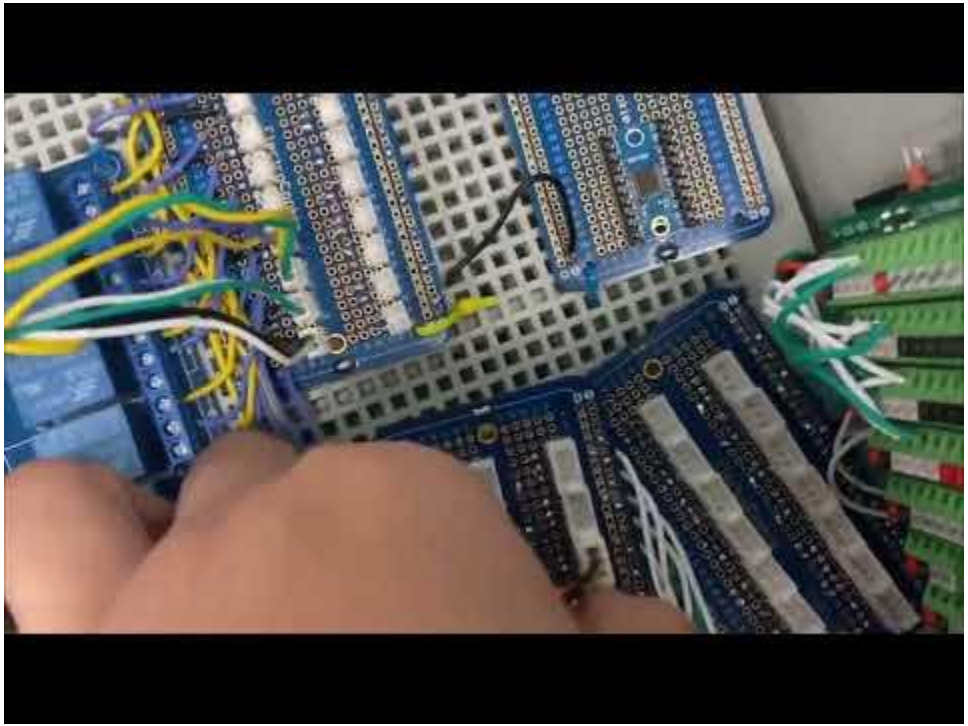

New tab
192.168.50.176:8000

Mechanical Engineering Irrigation System

- Combining mechanical structure with computer engineering prototype

On-Site Video Demo

Sensor Modularity Video Demo



Complete Budget

Item	Price	Quantity	Description	Link
Renogy 50W Monocrystalline 12V Solar Panel Kit	$89.99	1	Solar Panel and Solar Charge Controller	Amazon
ECI Power 12V 10Ah Lithium LiFePO4 Deep Cycle Rechargeable Battery	$54.99	1	Main Battery/Power Cell	Amazon
3/4" 12V DC U.S. Solid Solenoid Valve	$39.95	25	Main Solenoids controlled for water flow	Electric Solenoid Valves
ELEGOO 8 Channel DC 5V Relay Module	$10.99	2	Device Driver between Raspberry Pi and Solenoid	Amazon
HiLetgo TXS0108E 8 CH Bi-Directional Converter Module	$8.49	4	Bidirectional logic level converter to convert 3.3 V to 5V	Amazon
BANKEE 12V to 5V 5A Converter Step Down Regulator	$10.98	1	Stepdown Voltage Regulator to step from 24V sources to 12V devices (main voltage level)	Amazon

Songhe Capacitive Soil Moisture Sensor 5pcs	$9.71	5	Collecting soil moisture level for data	Amazon
DIGITEN Water Flow Hall Sensor Switch Flow Meter Flowmeter Counter 1-60L/min	$11.99	1	Collecting water flow rate	Amazon
G1/4 Pressure Transducer Sensor, Input 5V Output 0.5-4.5V / 0-5V Pressure Transmitter for Water (0-80 PSI)	$22.09	1	Collecting water pressure	Amazon
DHT11 Temperature Humidity Sensor Module Digital Temperature Humidity Sensor 3.3V-5V	$10.29	1	Collecting local humidity, temperature values	Amazon
Raspberry Pi 4 B 4GB RAM	$55.00	1	Main Microcomputer responsible for controlling all devices	Pishop.us
Arduino MEGA 2560	$38.00	2	Multiple ADC pinouts for analog-output sensors	Amazon
Total	**$1398.11**			

Design Implementation Challenges

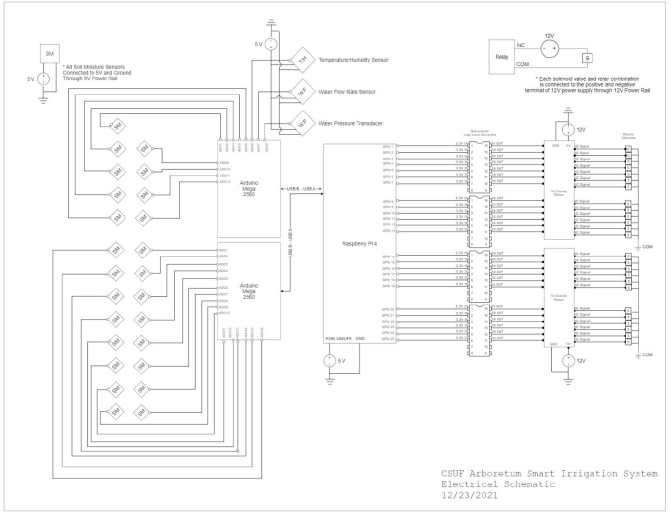
- Power distribution (different voltage values across components)
- Low 16-channel relay input voltage
  - Stepped up Pi's 3.3V to 5V using logic level converters
- Multiple accommodations for ME's and Arboretum's needs
  - Redesigned project to accommodate for ME team and the Arboretum
  - Returned old parts and bought new parts
- Researching sensor components given the constraints
  - Researched into project builds
  - Compared competing components

Future Work and Conclusion

- Install mounts for electronic devices
- Extend wiring to accomodate for sensors

- Continuing Web UI backend/frontend and beautification
- Parse and log sensor data in python code into database
- Integrate machine learning into Web UI

- Order components for future expansion
- Test power draw from system
- Get casing for sensors



Questions?