Project Eden: Smart Irrigation System for the CSUF Arboretum Nursery

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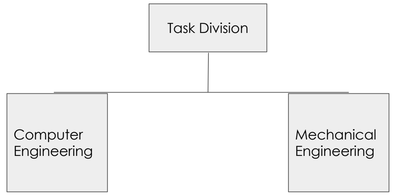
Background

- Due to impacts of COVID-19, the Arboretum of California State University, Fullerton has been understaffed and underfunded
- To ease increasing workload of the staff, we decided to automate the most time consuming task: watering of the nursery
- Task is divided into 2 teams: Computer Engineering and Mechanical Engineering



- Implement smart features into software such as:
  - fully flexible scheduling
  - water prediction based on sensors
- Host UI that controls system on school network to allow remote access on campus
- Take measurements and construct compatible frame
- Calculate pressure for pipe design
- Calculate the stress and if there would be need for support
- Research and integrate effective sprinklers

ME Design

Pipe system and Structural Support Design

- system is built to be easily replaceable and upgradable
- 10 sprinklers per table with a 3ft radius coverage
- Materials:
  (10) NetaFim VibroNet Sprinkler Green Nozzle , (3) U.S. Solid ¾" solenoid valve, (4) 10' sheets of ¾" PVC, (22) ¾" MPT adapters, (1) ¾" FPT adapter for hose connection, (1) gate valve for pressure release. (6) Metal Clamps per row. PVC Prime. Plastic tubing (30) Tees, (8) elbows, 10 12ft wood planks, 5 10 ft planks,

Materials for pipe system:

Material for structural support:

Building structure:

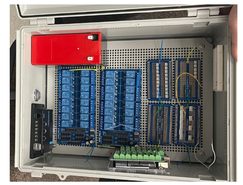
Beta prototype:

Alpha Prototype w/o sprinklers

Hardware

- Our system is capable of managing 28 total sensors: 1 temperature/humidity sensor, one water usage sensor, one water pressure sensor, and 25 soil moisture sensors.
- Every sensor can be swapped out and replaced with new ones
- Sensor values are logged, uploaded to the website, and used for water prediction and smart watering algorithms
- Sensor integration, website hosting, and solenoid valve control are all done on a Raspberry Pi 4 and two Arduino Megas
- Power distribution is covered by a solar panel, 12V Ion battery, solar charge controller, relays, logic level converters, and DC-DC converters.
- All electronic components except sensors and solar panel are inside a waterproof electronic container
- Modularity is accommodated for in the system by being able to handle all cases from best to worst (1 to 25 solenoids). Custom made socket perf boards are equipped with JST connectors and sockets for plug-and-play components (solenoids and sensors)

ARDUINO



Raspberry Pi

Design Advantages

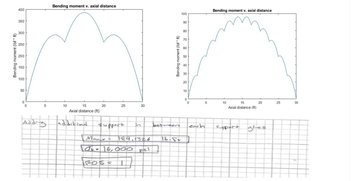
Although the idea of a smart irrigation system is not novel, Project Eden presents numerous advantages over commercial versions of the watering system. To combat constraints and reduce the footprint of the arboretum staff, we designed our smart system accordingly.

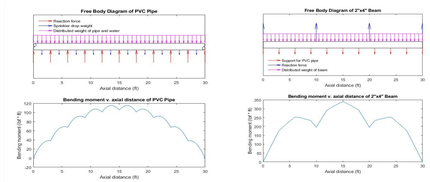
- Animals and Outdoor Elements:
  - Selected building materials and encasings are proved to be animal/weather resistant HDPE, sturdy non-metallic liquid conduits for wires, solid copper wire, and a weatherproof electrical box
- Completely solar powered and green energy friendly:
  - The system is self-powered through a solar panel and a respective solar controller connected to a medium capacity lithium-ion battery
- Remotely accessible and controllable:
  - Reliably connected to the university network, giving security to the arboretum staff through their unique credentials. Access to the controls of the system may also be remote anywhere within the vast university Wi-fi range
- Extreme customizability
  - System is configurable with three parameters: day of the week,time interval, watering duration, allowing for very high specificity in scheduling
- Expandability and Modularity
  - In the interests of the arboretum, the design is expandable for up to 25 solenoids and thus 25 rows of plants! Likewise, the system can be reduced down to only 1 row. The hardware, software, and physical design is modular to handle whatever the Arboretum wants for the system size.

Final Measurement

Sample calculations for Flow rate, Pressure loss and simulations of water flow using SOLIDWORKS SIMULATION
Structural Analysis:

- Structural Analysis on the one table design creates a bending moment diagram.
- Using sturdy wood as structural support will gives a safety factor of 1.71.
- Individually the structure would not hold on its own.

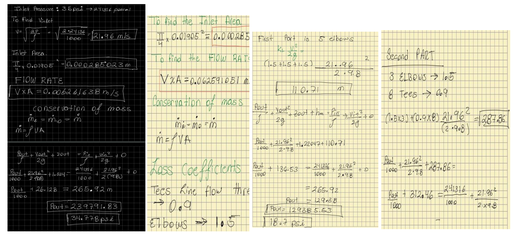


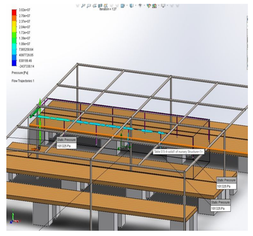


Calculations for Stress Analysis, Pressure loss and Flow rate

Simulation for Flow rate

- Pressure for each drop is approximately 18psi.





Software

- The two Arduino are tasked with receiving 16 analog inputs each and formatting that data to send to the Raspberry Pi
  - Arduino 1: Receives 1 water usage sensor, 1 water pressure sensor, 1 temperature/humidity sensor, and 13 soil moisture sensors
  - Arduino 2: Receives 16 soil moisture sensors
- The Raspberry Pi is tasked with logging the sensor data sent from the Arduinos, hosting the website for the nursery, and running watering algorithms
- Website hosting is coded using the Python library Remi

Row 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Start:		End:		Interval:		Duration:	
Row 2	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Start:		End:		Interval:		Duration:	
Row 3	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Start:		End:		Interval:		Duration:	
Row 4	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Start:		End:		Interval:		Duration:	
Row 5	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Start:		End:		Interval:		Duration:	

- The two algorithms in development are a water prediction algorithm and a watering recommendation feature based on weather and sensor data

REMote interface

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