Farms of the Future

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Overview

Hydroponics and Microgreens

Growing crops is an intensive task, and takes a significant amount of effort for farmers. Hydroponics is a growing strategy that incorporates more control over the crop-growing process. Hydroponics strategies allows farmers to efficiently monitor and control the growth of their crops through tweaking variables like temperature, lighting, and preventing the harmful effects of bugs and weather. Many hydroponics systems are dedicated to growing microgreens, which are specialized vegetables that are harvested in ear;y stages of growth.

Project Challenge

Our challenge is to design a water delivery system for use with growing microgreens in a hydroponics setup. This includes adjusting fertilizer and pH content, temperature control, remove video monitoring, and data logging capabilities. This system must give the user full control over the plant watering periods, and over the content of the water. This product is intended to lower the cost of cultivating microgreens by significantly reducing manual intervention, and to provide monitoring/control capabilities for the system.

SYSTEM CAPTION

Requirements

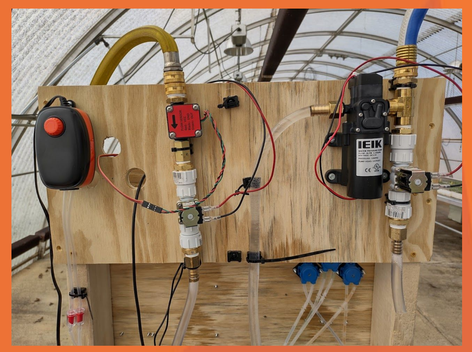
- *Temperature control*
- *pH and nutrient control*
- *Watering control*
- *Remote control capabilities*
- *Remote monitoring*
- *Include a data log that can be queried and reviewed historically*

Flow

The water flow design has 2 primary systems:

- Inflow
  - **Flow sensor** - measuring flow from water hose
  - **Electrical solenoid** - turn flow on/off
- Outflow
  - **Main pump** - Pump treated water to plant
  - **Electrical solenoid** - activate dump sequence

The system also includes a backflow line from the plant.



Sensing

An array of sensors was placed in the bucket to monitor the required data points. This array includes three water level sensors, a pH sensor, a temperature probe, and an electrical conductivity sensor. This combination of sensors allows the system to constantly update the user about the quality of the water and automatically keep the water in a condition that is healthy for the microgreens.

Actuation

- **Diaphragm Pump** - pump used for delivering water from the reservoir to the plants
- **Peristaltic Pumps (x3)** - three small pumps used for adding precise amounts of additives
- **Flow Valves (x2)** - a pair of electronically-controlled valves for controlling flow

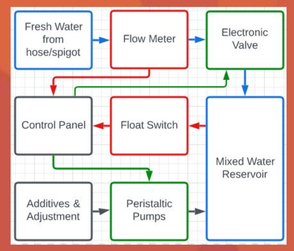
All actuators are powered by 12v power and controlled by DFRobot peripheral motor controllers and relays.

Controls

A Raspberry Pi acts as the main controller, delivering an easily controlled GPIO, internet connectivity, and a basic OS. The Pi interfaces with the user interface, the USB camera, and the controlled peripherals.

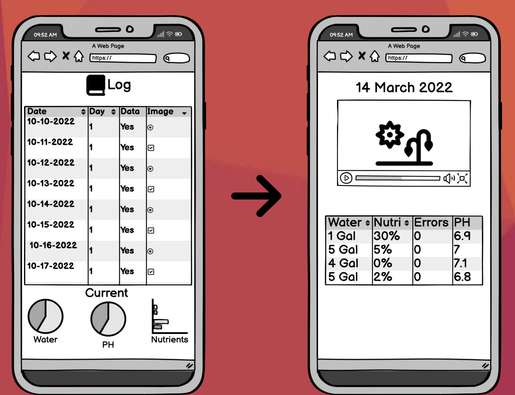
The Pi is complemented by an ATMega32u4 shield which offers low-level capabilities necessary for interfacing with sensors, such as hardware interrupts and an analog-to-digital converter. This is solely responsible for interfacing with sensors and reporting that data to the Pi via serial communications.

The primary software consists of a Python script running on the RPi, responsible for managing the control flow of the system. Sensor data and other relevant information is logged to a text file on the Pi.



User Interface

The user interface is going to act a s the primary point of interaction between the system and the users, We are going to host the user interface on a python flask server. The webpage is going to display a wide variety of features so that the users get a lot of flexibility in terms of customizing and controlling the system.



Validation

The team will conduct a series of tests to validate different aspects of the system. The water distribution system will be tested to ensure that water is being distributed evenly throughout the system. This will help to promote healthy plant growth and prevent the buildup of stagnant water.

The reproducibility of the system will also be tested to ensure that the system can be easily replicated by other users. This will help to ensure that the hydroponic system can be used widely and effectively. The user interface will be tested for its user-friendliness, ensuring that users can easily navigate the system and make necessary adjustments. Finally, the accuracy of water quality monitoring will be validated to ensure that users can accurately monitor and maintain the water quality necessary for healthy plant growth. These tests will ensure that the hydroponic system is efficient, effective, and user-friendly, providing users with a reliable and sustainable solution for growing plants.

Implications/Conclusions

CCAM will be using this product for research purposes. It could be used to test out varying water quality conditions and their effects on plant growth.

A farmer could use our product to automate the water delivery system. This will allow growth without monitoring for weeks.

Future Improvements

- Better base setup
- More modular
- Broader scope

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LEFT TO RIGHT: Nathan Hayes, Artre Turner, Vitha Anumolu, Avish Kandi, Thomas Cavagnaro, Daniel Sullivan

CHALLENGE

To automate the water delivery system for an indoor microgreens aquaponics system such that the system is less reliant on human intervention. The system will need to regulate water storage, water delivery, and water quality (as measured by temperature, pH, and electrical conductivity). The system included a means for remote monitoring, as well as a digital interface for system control and monitoring.

Nathan Hayes Richmond, Virginia

B.S. in Electrical Engineering (Controls, Robotics, Autonomy)

Aspirations: I am planning to get my Master of Electrical Engineering and go into a career in robotics or factory automation.

Class Comment: I've enjoyed collaborating with people outside of my major and learning about the intersection of electrical controls & the environment.

Artre Turner Chesterfield, Virginia

B.S. in Industrial & Systems Engineering

Aspirations: I will attend Purdue University's engineering education PhD program. I aspire to engage in purposeful research and bring about significant advancements in the field of higher education.

Class Comment: This class has taught me the practical steps involved in creating a product. The process revealed my product-building strengths and weaknesses.

Vitha Anumolu Chantilly, Virginia

B.S. in Industrial & Systems Engineering

Aspirations: I plan to start my career working as a Product Manager, eventually working towards starting my own business in a couple years. I aspire to bring meaningful change to whatever environment I'm in and inspire others.

Class Comment: This course gave me hands-on experience with systems engineering and electrical engineering concepts that have taught me a lot. Working with different disciplines was a huge learning experience.

Daniel Sullivan Chantilly, Va.

B.S. in Electrical Engineering (Controls, Robotics, Autonomy)

Aspirations: I want to be on the leading edge of whatever industry I work in. I want to push myself to not take the easy route but reach the limits of my potential. I hope to keep this mindset in whatever I do.

Class Comment: Interdisciplinary Design has been the most useful course I've taken during my studies. The soft skills I've developed while working with industry sponsors, faculty, and students of other majors will be vital in the workforce. Virginia Tech would greatly benefit students by shifting all capstones to an interdisciplinary format.

Thomas Cavagnaro Hillsborough, NJ

B.S. in Mechanical Engineering

Aspirations: I am looking forward to working in the field of engineering, and being involved in projects that are meaningful. I am hopeful that someday I can step into a leadership position and oversee projects like this one.

Class Comment: Interdisciplinary design has been very instrumental in my development as a team player. It has shown me how to work with others who come from different backgrounds and have different skills. The specialization of knowledge that our team members have is one of the biggest reasons for this group's success in developing a working product.

Avish Kandi Hyderabad, India

B.S. in Computer Science, Minor in Innovation

Aspirations: I look forward to working in industry and using the experience I gained from this class. I aspire to manage my own engineering company in the future.

Class Comment: This class was a great experience as I got to work with likeminded individuals on a project that required all of our expertise from different backgrounds.