Spirit Tank

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Introduction

The Spirit Tank is an automated system for cultivating Spirulina, a nutritionally dense blue-green algae. The Spirit Tank aims to automatically maintain important aspects of the process such as the water level, temperature and pH to make growing Spirulina easier, and faster, using LEDs to improve the Spirulinas growth rate. The raw Spirulina grown would be greatly beneficial as a nutritional supplement for almost everyone!

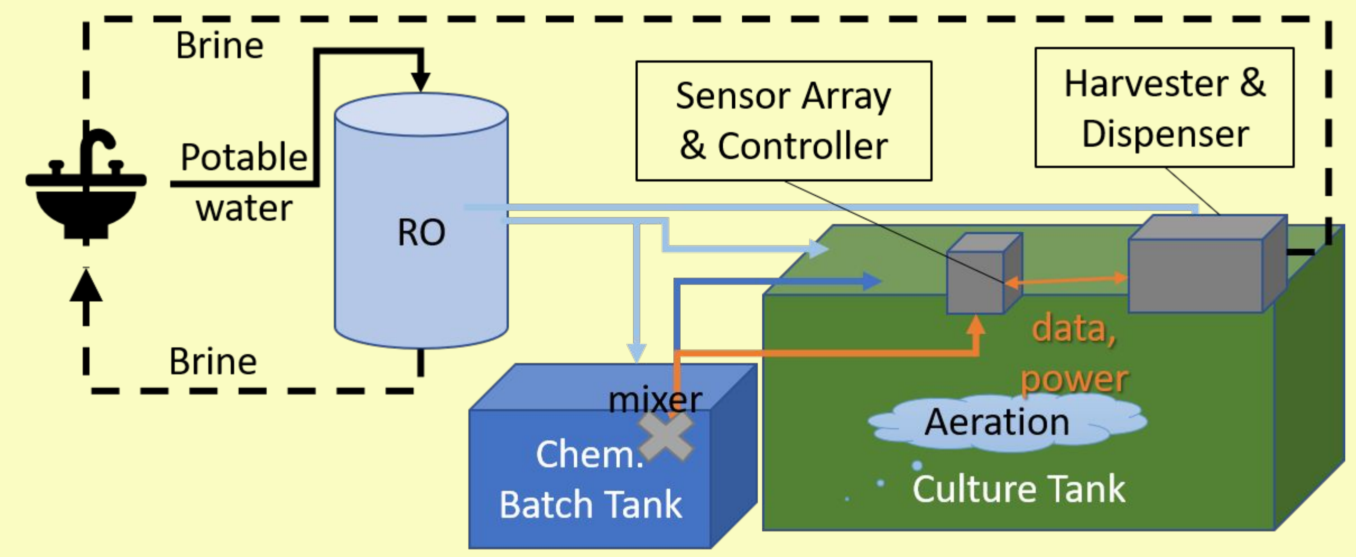
Problem

Currently, it takes too much time or too much money for people to supplement their diet with fresh, nutritionally dense, spirulina algae superfood. The main issue our project aims to address is that growing and harvesting fresh Spirulina requires a considerable amount of attention, time and technical skill. By automating the cultivation process, we want to make it easier for anyone to grow Spirulina and to significantly increase growth rate and output from a small tank.

Available Solutions

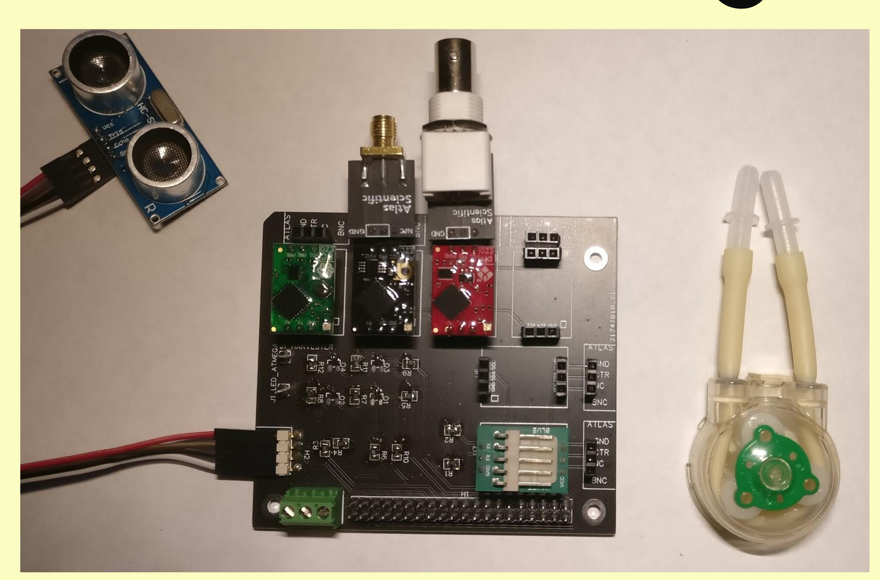
- Raw spirulina is prohibitively expensive to ship and distribute, but can be grown using DIY solutions.
- Powdered spirulina supplements exist, but the drying process results in an unpleasant taste with only 20% the nutritional value of fresh spirulina.

Schematic



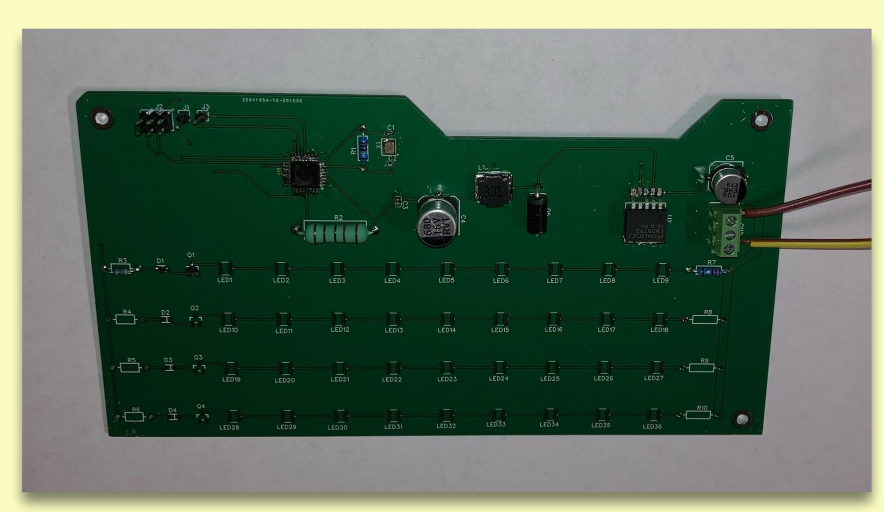
- Project scope: sensor array and controller portions.

Assembled Components & Program View



Main Board

- Main board for connecting between a Raspberry Pi and peripherals.
  - Sensors and peristaltic pumps via I2C circuits.
    - pH
    - Salinity
    - Temperature.
  - Ultrasonic Sensor for water level measurement.
  - Signal to Heater
  - Signal to LED controller board



LED controller board

- LED's need to be on for a precise time to maximize growth, while avoiding bleaching of the culture.
  - Uses an ATmega328P microcontroller to generate a precise PWM signal to the LED driver circuitry.
  - 24 V is supplied to the board with the LEDs using this with a current limiting resistor and a voltage regulator supplies 5 V to the ATmega328P microcontroller.

Control Program

- Implemented on a Raspberry Pi 4, the program takes in data from the main board, determines what changes are needed and implements those changes.
  - Implemented using Python
- UI Interface to display systems values, Safety state and provide user input.
  - Implemented using QT

Testing

- Used ATmega328P development board to test code along with a logic analyzer to verify the pulse widths of the signal turning on the LEDs.
- Using I2C communication to interface with the Atlas Scientific components, ran functional tests for measuring pH, salinity, and temperature.
- The pH reading requires time to settle and we either did not calibrate the meter correctly, or the sensor we used was not as accurate as we would have liked. All other readings were accurate and precise enough for our needs.

Conclusions

Unfortunately, development stagnated in large part due to Covid-19, and the mitigation policies taken by both the University and State Government each having significant impacts on us. As it is, we were not able to implement everything we set out to and the project serves as a proof of concept to refine the processes and control of the system.

Future improvements would include:

- Replacing the Raspberry Pi with a microcontroller that is able to perform the needed functions more concisely and accurately.
  - The Beagle Bone Black device looks to fulfill this as it has real time operation and the ability to produce precise PWM signals and other desirable features.
- Replace the Atlas Scientific components as they are proprietary.

Once this system is implemented, tested and refined to a minimum viable product we could implement a prototype on a custom made PCB.

Acknowledgements

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