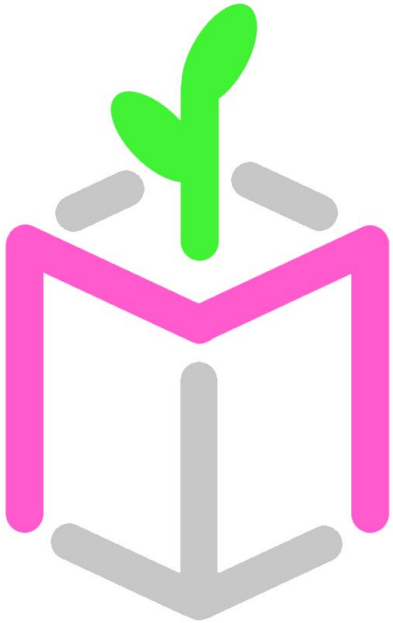


iGroBox

Greg Cortazzo, Lucas Moiseyev
Team B8

Application Area and Solution approach

- Application Area: Microgreens Cultivation
  - High in nutrition and expensive
  - Fast time-to-harvest
  - Difficult and time-consuming to grow
- MiGroBox seeds, waters, and raises crops until they are ready for harvest

Implementation Plan

- **Software:**
  - FreeRTOS running on ESP32
  - GRBL CNC firmware ported to run on ESP32 with FreeRTOS using interrupts
  - Custom grow routine running on ESP32
  - Custom website interface built from Django framework
- **Electrical Hardware:**
  - ESP32 Microcontroller
  - TMC2209 stepper motor drivers
  - Off-the-shelf motors, sensors, light strips, relay board, power supply
  - Custom main board to plug everything in, handle voltage distribution
- **Mechanical Hardware:**
  - Vacu-formed seed hoppers from 3D printed molds
  - 3D printed seed distributor pawl and miscellaneous parts
  - Linear rails for CNC
  - Mylar insulation sheeting walls
  - 80/20 aluminum extrusion frame
  - PVC and plastic piping plumbing

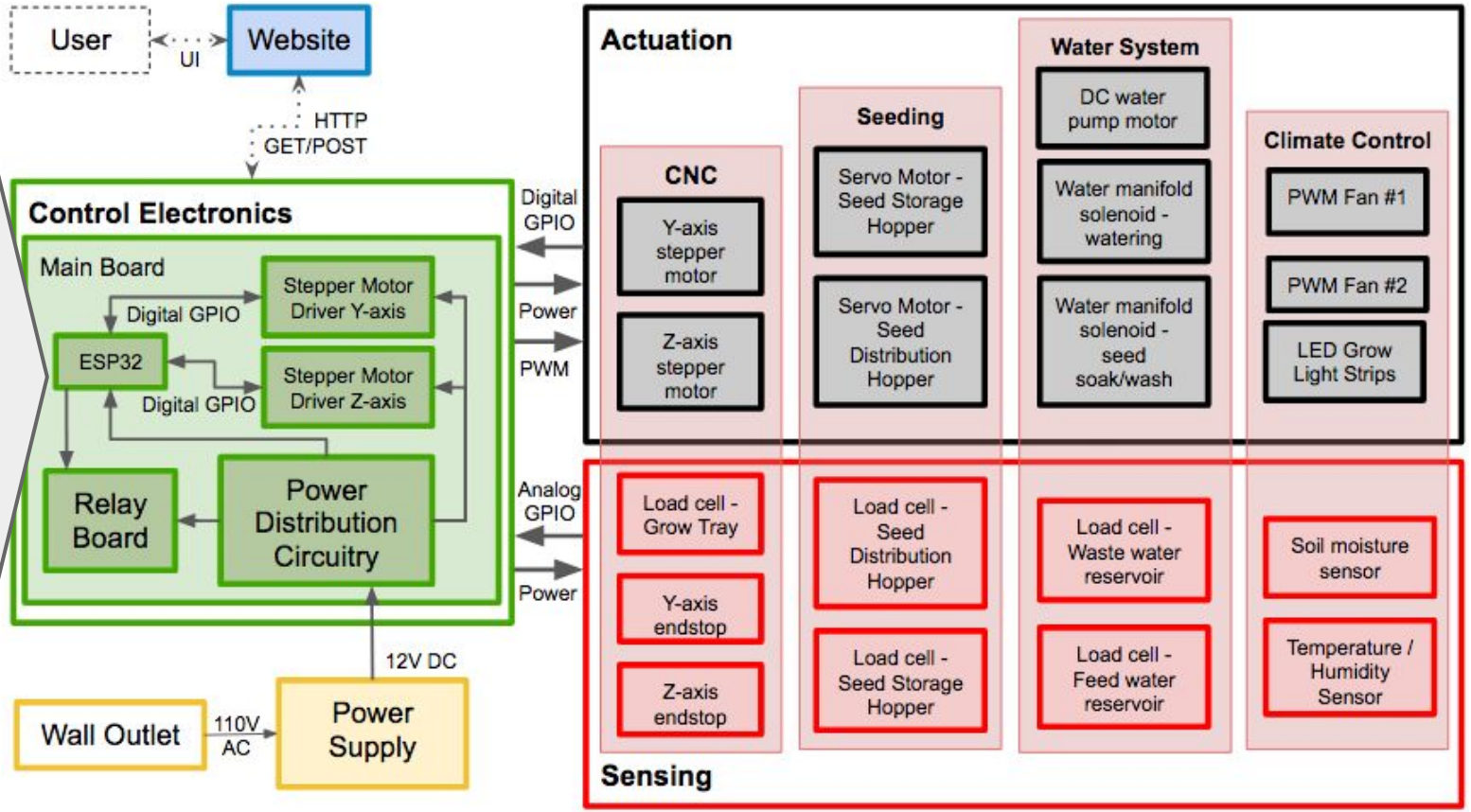
System Specification

Embedded Software Stack

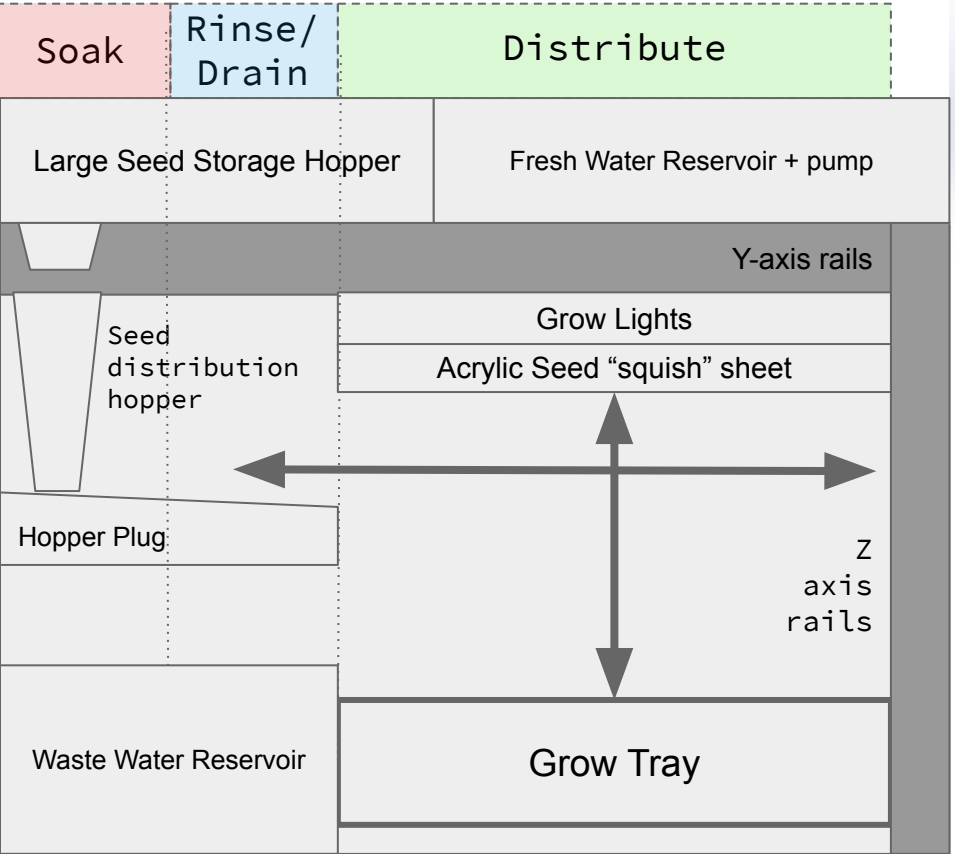
Top Level Routines:
Poll sensors, track time, send web updates, etc.

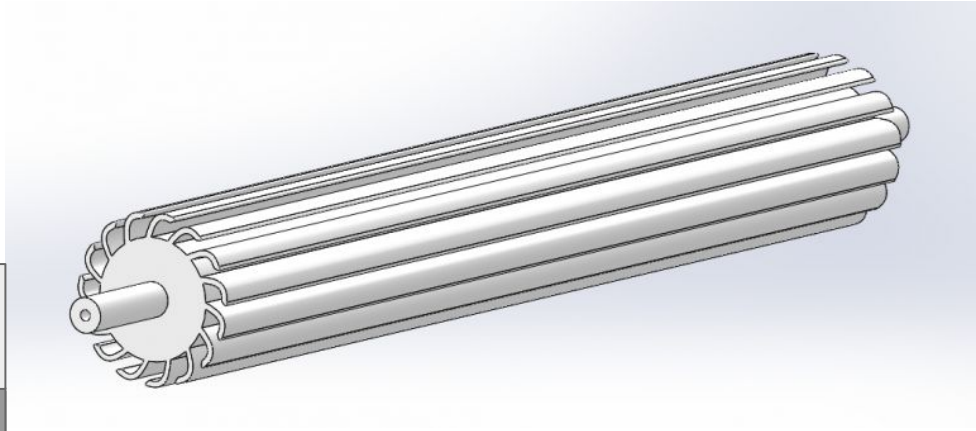
CNC Firmware:
GRBL

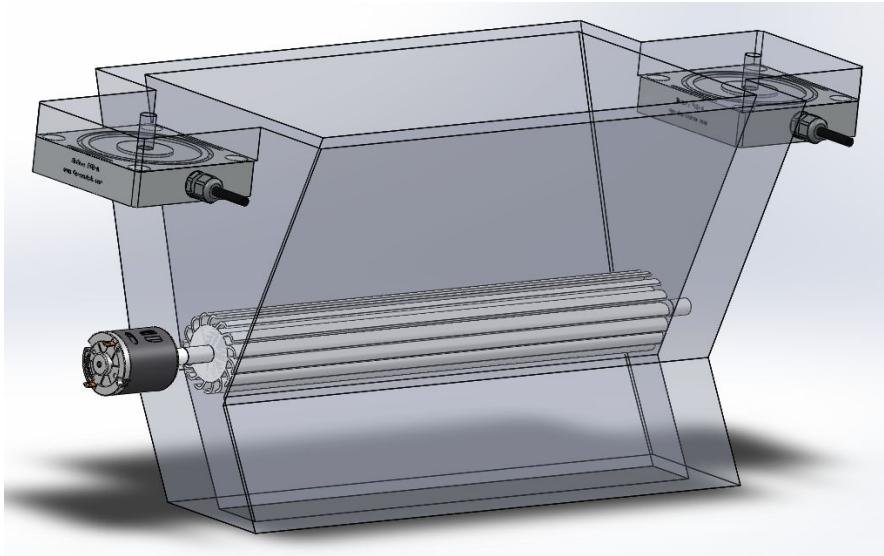
OS:
FreeRTOS



Hardware Overview



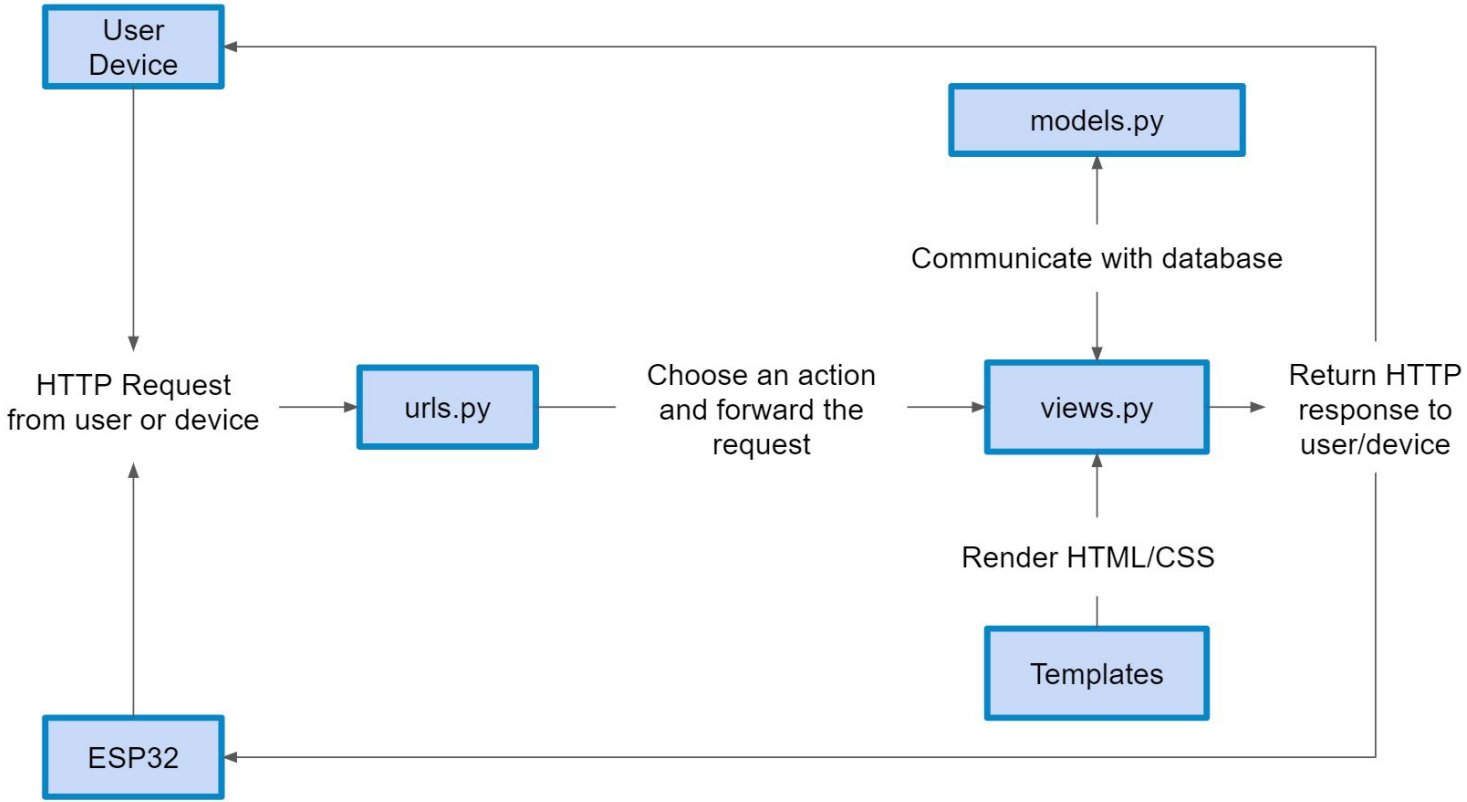




Embedded Software Overview

- ESP32 running FreeRTOS
  - PWM and ADC drivers
- GRBL CNC firmware
  - Already ported to ESP32 by 3rd party
- Custom software to run grow routine, interface with website
  - Interrupt-based

Web Application Overview



Revised Requirements - Features

1. **Climate control/monitoring**
    a. Water irrigation system
    b. Full spectrum lighting
    c. Air circulation
    d. Temperature sensing
    e. Humidity sensing
2. **Seed storage, distribution, and care**
    a. Long term seed storage
    b. Seed dispensing
    c. Seed rinsing and soaking
    d. Seed distribution
    e. Seed pressing
3. **Seed grow regime pre-sets**
    a. Saved optimal values for at least the plant varieties grown over the course of the semester project (two so far)
4. **WiFi user interface**
    a. Custom website
    b. Device connected website interface via WiFi 24/7

Revised Requirements - Technical Metrics

1. **Seed density/distribution:** Seed density at any given square inch of the grow tray can be *maximum 33% higher* than target density
2. **Water spread/coverage:** *100% coverage/saturation* and drainage *within 20 minutes*
3. **Seed weight dispensing accuracy:** Weight of seeds dispensed by storage hopper into distributor *within 1 gram* of target
4. **Watering Frequency:** At least once every *12 hours*
5. **Website latency:** Time-to-first-byte latency of *<2 seconds*

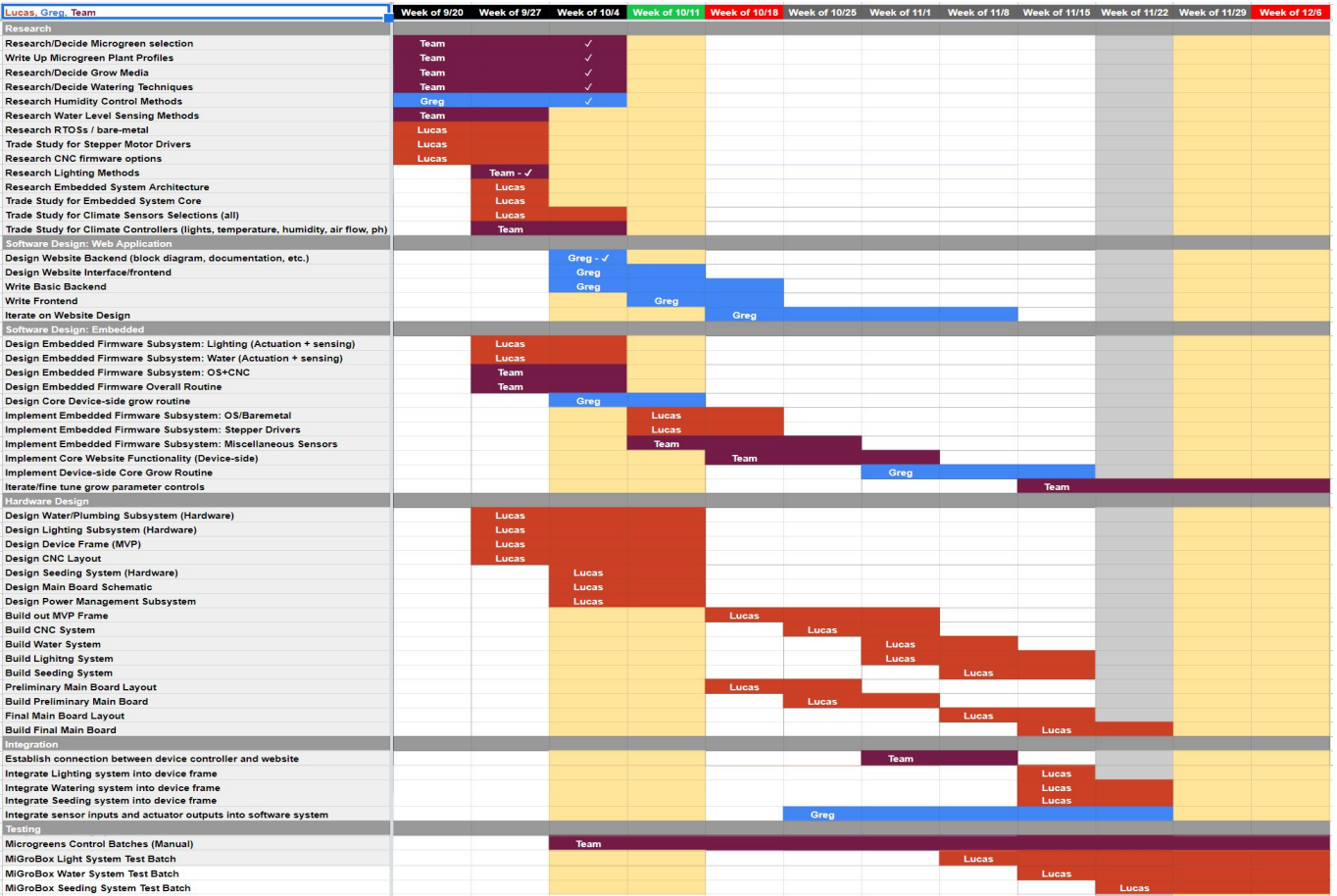
Revised Requirements - Project Validation

1. **Yield Ratio:** Seed-to-greens weight ratio produced by MiGroBox must be *>85%* of manually-grown control group
2. **Labor-Hours:** Time taken to cultivate microgreens via MiGroBox must be *<70%* that of manually-grown control group
3. **Wage Comparison:** Metric combining yield ratio and labor-hours with seed costs and miscellaneous overhead must *surpass minimum wage ($7.25/hr)* and increase over manually grown wage by *at least 20%*

Risk Factors and Mitigation

- Design/execution details:
  - Temperature homeostasis → Add mylar layers
  - Seed soaking/draining mechanism → Continue to refine machine tolerances
- Uncertain externalities of automation
  - Additional machine maintenance may lead to increased labor time → Refine actuator control accuracy
  - Failure rate of hardware is unknown → Test constantly, place parts as needed
- Testing/evaluation
  - Testing highly dependant on real grow data → Run staggered tests, 2x per week
  - Takes a week to conduct a single, full start-to-finish system test → test subcomponents separately as needed
  - Failed week of crops could rob us of valuable data → Weekly trials

Project Management and Revised Schedule



- Exploring vacuforming design/ manufacturing via TechSpark
- Starting manual grow cycle (waiting on seeds to arrive)
- Starting website design
- Starting main board layout