TBD Gardening Project Name - Group 9

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UCF Senior Design Fall 2022 - Spring 2023

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1 Executive Summary

New gardeners typically struggle getting their garden started due to a lack of tending to their plants. This project seeks to solve many of the problems that new gardeners have through sensing and control. The main issues with plant growth relate to soil composition, soil moisture, temperatue, and sun light. This project seeks to use optics to measure the soil moisture and composition; then an MCU will capture this data and control solar shades to control sunlight and solenoids to control watering. A web component will be included to check the weather as well as notify the user of impending weather events that could affect their plants adversively (frost or heat wave). The entire system will be powered with solar panels that are capable of tracking the sun through the sky and can act as blinds over the plants.

This project all starts with scoping out the project. The team has immediately compiling a list of must-have requirements and some things the team would like to accomplish as "nice to haves". The team started this process by looking at all the similar projects that have already been done and looked at all the ways the team can expand on the work they have already accomplished. For example, the team liked the weather aspects of a project for getting rain information; a problem the team were thinking about was how to get the system in as much of a "set it and forget it" state as possible as it pertained to frost. The solution is to integrate with a weather service online and send notifications when there is a frost or freeze advisory.

After assembling the list of requirements, the team set out to create a high-level functional block diagram for each of the subsystems. This helps the team see where the different systems integrate for the future as well as breaking out all the different components that may need to be purchased.

The ultimate novelty in this project is all of the sensing that will be done through spectroscopy. The team has found a plethora of research on the topic and has started familiarizing themselves with the limitations and capabilities of the available technology. Ideally, the team would like to find a scalable solution to the sensing in which the optical sensing could be attached to a drone or satellite to survey fields for farming.

2 Project Description

2.1 Project Background

Introduction

Steal problem statement from executive summary.

Motivation

Why are we doing this?

2.2 Project Objectives

Goals and Objectives

Function of Project

2.2.1 Project Specifications

Requirements

The MCU subsystem should:

- Read local sensor data (e.g. sunlight, soil moisture, temperature)
- Adjust parameters of local modules (e.g. shade, water, nutrients)
- Interpret user settings and adjust parameters of modules accordingly
- Fulfill web requirements with at least two computers/controllers

It would be nice for the MCU subsystem to:

- Fulfill web requirements with one computer/controller
- Have a local user display (e.g. LCD, dot matrix, segmented)

The direction of power in this system:

- Power generated through a wall outlet
- AC/DC converter
- Power supply
- MCU
  - Regulators
  - Sensors
  - Mechanics
  - CPU

It would be nice to have:

- Solar power, with the flow of power as follows:
  - Solar panels
  - Solar power bank
  - Power supply
  - MCU

- Use the solar panels as blinds to be able to open and close as well as collect energy

The Sensing Capabilities of the project should include:

- Infrared Spectroscopy Sensor which detects:
  - Soil Moisture
  - Soil Temperature
  - Soil OH group content (acidity)
- Infrared Spectra signal processing

It would be nice to have:

- Scanning Capabilities for checking various parts of the garden bed
- Soil Nutrient Estimation and other variables possible via IR Spectroscopy

The web component of the project should:

- Attach to a weather API to receive:
  - Rain
  - Sun light
  - Temperature
  - Frost warnings
  - Humidity
- Alert users of conditions outside of automatic control (i.e. soil composition and frost)
- Change control parameters:
  - Sun light
  - Water
  - Soil parameters
- Have an intuitive user interface
- Communicate with the MCU

It would be nice to have the web component:

- Set control parameters based on presets for plants
- Get plant data from the web to pass to MCU
- Communicate over secure channels

2.2.2 Project Block Diagram

2.3 Marketing Requirements

3 Research

3.1 Previous and Related Works

3.2 Related Technologies

3.3 Part Selection

3.3.1 Controller Subsystem

At minimum, any chosen single-board computers (SBCs) or microcontrollers (MCUs) shall support natively, or by addition of a module, these features and traits:

- Analog-to-digital converter (ADC)
- In stock and available to order
- JTAG module or equivalent
- Module communication bus (UART, I2C, SPI)
- Onboard CPU sufficient for our purposes
- Onboard memory sufficient for our purposes
- Pins dedicated to analog input
- Pins dedicated to digital I/O
- Wireless communication protocols (e.g. BLE, 802.11)

These features would be "nice to have" on any SBC or MCU selected, but are not required:

- Digital-to-analog converter (DAC)
- microSD card slot
- Onboard battery
- Onboard GPU
- Onboard nonvolatile memory
- Operating system (OS) support

- Pins dedicated to pulse-width modulation (PWM)
- Timer(s) and an RTC
- USB compatibility

The following selections, not listed in any particular order, match the above criteria and are being considered for selection:

Single-board computers (SBCs)

- Texas Instruments BEAGL-BONE-BLACK ($53, possibly free)
  - Processor(s): Sitara AM3358BZCZ100 (Single ARM Cortex-A8 @1GHz), SGX530 3D (GPU)
  - Memory: 512MB DDR3L, 8GB eMMC
  - Communications protocols: 10/100baseT, USB2.0, UART, I2C, SPI
  - Features: 8-channel 12-bit SARADC, JTAG, microSD, HDMI, McASP, LCD controller, Timers (8), RTC, WDT, PWM
  - OS compatibility: Linux
  - Voltage requirements: 5V
  - Physical size: 3.4" × 2.1"
  - Availability: Digikey, Mouser, Newark, OKdo
  - Notes: wireless module needed
- PINE64 Quartz64 Model B ($60)
  - Processor(s): Rockchip RK3566 (Quad ARM Cortex-A55 @1.8 GHz), Mali-G52 2EE Bifrost (GPU)
  - Memory: 4GB LPDDR4, optional eMMC
  - Communications protocols: 10/100/1000baseT, 802.11b/g/n/ac, BT5.0, USB2.0/3.0, UART, I2C, I2S, SPI
  - Features: 4-channel 10-bit SARADC, microSD, HDMI, Timers, RTC, WDT, PWM
  - OS compatibility: Armbian, Manjaro ARM, ... (community-based releases)
  - Voltage requirements: 5V
  - Physical size: 3.3" × 2.2"
  - Availability: PINE64
- PINE64 A64-LTS ($40)

- Processor(s): Allwinner A64 (Quad ARM Cortex-A53 @1.152 GHz), Mali400MP2 GPU
- Memory: 2GB LPDDR3
- Communications protocols: 10/100/1000baseT, 802.11b/g/n, USB2.0, SPI, TWI, UART
- Features: 6-bit KEYADC, microSD, Timers, RTC, PWM
- OS compatibility: SOPINE
- Voltage requirements: 5V
- Physical size: 5.2" × 3.1"
- Availability: PINE64
- Notes: wireless module needed

Microcontrollers (MCUs)

- Texas Instruments LAUNCHXL-CC26X2R1 ($40, possibly free)
  - Processor(s): TI CC2652R (Single ARM Cortex-M4F @48 MHz)
  - Memory: 256KB ROM, 352KB flash, 80KB + 16KB + 4KB SRAM
  - Communications protocols: BLE5.2, Zigbee, Thread, UART, I2C, I2S, SPI
  - Features: 8-channel 12-bit ADC, 8-bit DAC, JTAG, Timers, WDT, RTC
  - Voltage requirements: 3V3, 5V
  - Physical size: n/a
  - Availability: TI
- Texas Instruments MSP-EXP430FR6989 ($20, possibly free)
  - Processor(s): MSP430FR6989 (Single RISC @16 MHz)
  - Memory: 128KB FRAM, 2KB SRAM
  - Communications protocols: UART, SPI, I2C
  - Features: 16-channel 12-bit ADC, JTAG, Timers, RTC, WDT
  - Voltage requirements: 3V3, 5V
  - Physical size: n/a
  - Availability: TI
  - Notes: wireless module needed
- Texas Instruments LAUNCHCC3220MODASF ($60, possibly free)
  - Processor(s): CC3220MODASF (Single ARM Cortex-M4 @80MHz)

  - Memory: 1MB flash, 256KB RAM
  - Communications protocols: 802.11b/g/n, UART, I2C, SPI,
  - Features: 4-channel 12-bit ADC, JTAG, McASP, Timer, WDT
  - Voltage requirements: 3V3, 5V
  - Physical size: n/a
  - Availability: TI

- Raspberry Pi Pico W ($6)
  - Processor(s): RP2040 (Dual ARM Cortex-M0+ @133MHz)
  - Memory: 264KB SRAM
  - Communications protocols: 802.11n, USB1.1, UART, SPI, I2C, PIO
  - Features: 4-channel 12-bit SARADC, Timer, RTC, WDT, PWM
  - Voltage requirements: 5V, 3V3 I/O
  - Physical size: 2.0" × 0.83"
  - Availability: Digikey, Canakit
  - Notes: wireless module needed

- Arduino Due ($48)
  - Processor(s): Atmel SAM3X8E (Single ARM Cortex-M3 @84 MHz)
  - Memory: 512KB flash, 96K SRAM
  - Communications protocols: 10/100baseT UART, TWI, SPI, USB2.0,
  - Features: 16-channel 12-bit ADC, DAC, JTAG, Timer, WDT, PWM
  - Voltage requirements: 3V3
  - Physical size: 4.0" × 2.1"
  - Availability: Arduino

- Arduino Nano 33 BLE ($28)
  - Processor(s): Nordic Semiconductors nRF52840 (Single ARM Cortex-M4 @64 MHz)
  - Memory: 1MB flash, 256K SRAM
  - Communications protocols: BLE5, 802.15.4-2006, NFC, UART, SPI, I2C, I2S, USB2.0
  - Features: 8-channel 12-bit ADC, Timer, RTC
  - Voltage requirements: 3V3
  - Physical size: 1.8" × 0.71"

- Availability: OKdo

Ultimately, SBCs may not need to be used if a cURL library is used on an MCU in conjunction with Amazon EC2 services.

3.3.2 Power Subsystem

3.3.3 Sensing Subsystem

4 Design Constraints

4.1 Related Standards

4.2 Economic Constraints

4.3 Time Constraints

4.4 Equipment Constraints

4.5 Safety Constraints

4.6 Environmental Constraints

4.7 Manufacturability Constraints

4.8 Ethical Constraints

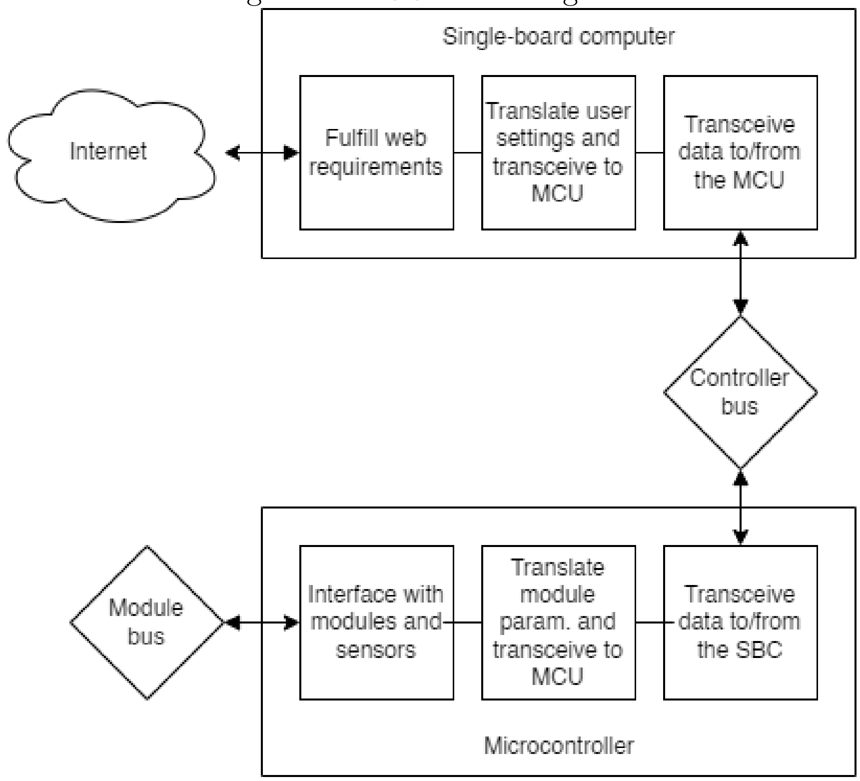
4.9 Sustainability Constraints

5 System Hardware and Software Design

High level overview of design

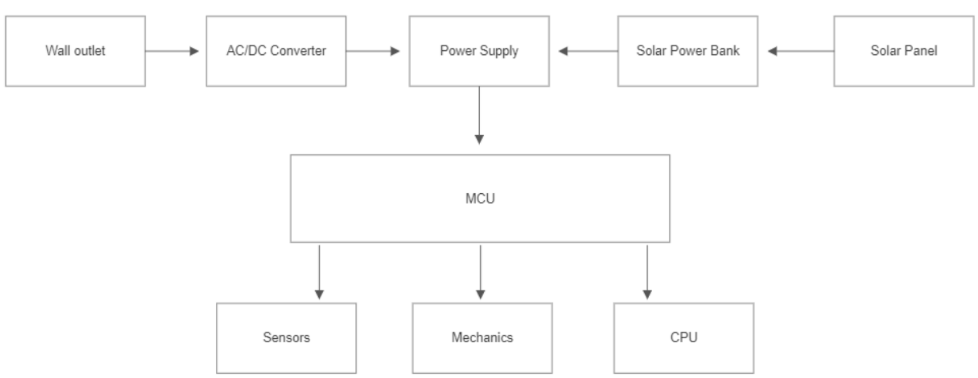
5.1 Controller Subsystem

Figure 1: MCU block diagram



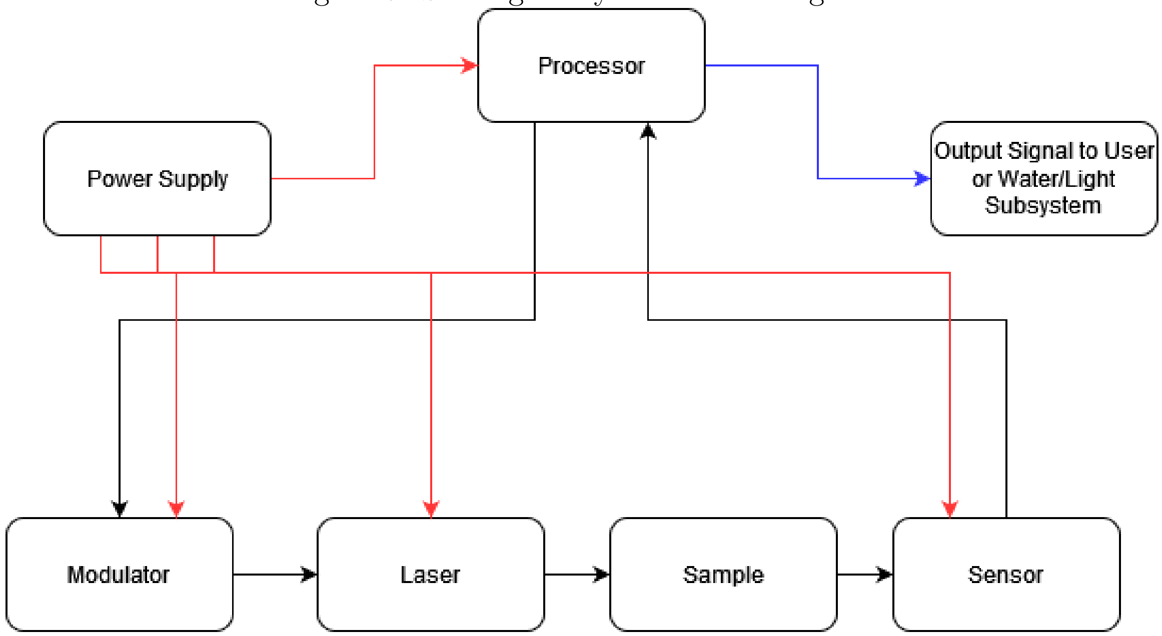
5.2 Power Subsystem

Figure 2: Power subsystem block diagram



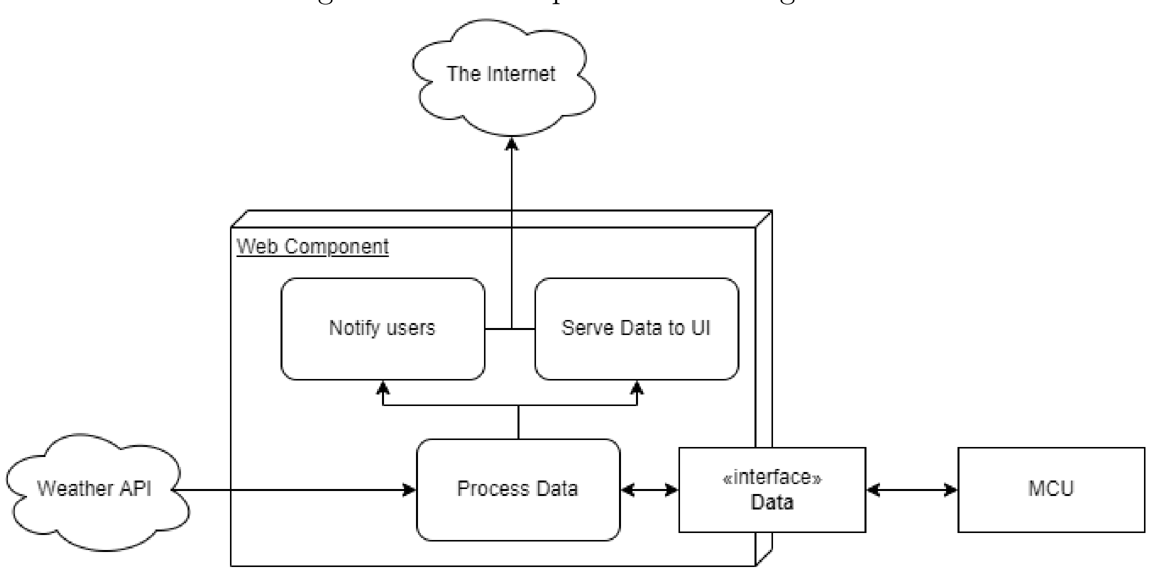
5.3 Sensing Subsystem

Figure 3: Sensing subsystem block diagram



5.4 Web Subsystem

Figure 4: Web component block diagram



6 Testing

7 Administrative Content

7.1 Milestones

From a project management perspective, the team will be utilizing Agile to get quick turn arounds on small deliverables. Choosing to use agile, the team will also be using Jira to track progress and add reports throughout the process. A high-level of the goals by semester can be found below.

7.1.1 Fall

- Select components for each subsystem
  - Document selection reasoning
  - Order to ensure on-time delivery
- Model physical bed
- Build physical bed
- Understand how subsystems will integrate:
  - Communication protocols (REST, I2C, SPI, DSP, etc)
  - Power requirements
- UI for Web subsystem

7.1.2 Spring

- Test subsystems in isolation
- Start integrating subsystems
- Control scheme for moving solar panels with sun and to provide shade
- Web API complete
- MCU coding complete
- Stretch goals

7.2 Budget

Subsystem	Estimated Cost	Comment
MCU	$60	The MCU, wiring harness
Power	$200	Solar panels, batteries, control system
Sensing	$100	Components for sensing, optical sensors
Web	$30	Web service pricing
Non-Subsystem	$100	The plant bed, soil, water, fittings, etc
Total	$490	

Table 1: Breakdown of budget by subsystem