Project Proposal

Future Greenhouse/Plant Nursery Automation

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ECE 558 - Winter 2022
Version 1.0 – 02/28/2022

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Project Description

Problem Statement:

Growing plants from seed is a great way to start gardening earlier in the season, but this can be a time consuming endeavor with a high chance of failure for even experienced gardeners. Growing from seed lets you select your own varieties, benefits the environment by reducing the carbon footprint of your food, it is sustainable, and economical.

The goal with seed starting is to have your seedlings ready to go outside when the weather is favorable, which generally requires starting the seeds six to eight weeks before the last frost. Each plant has unique seed-starting requirements, and can be fussy and difficult to start in the dead of winter. This project is designed to ease the burden of starting a garden from seed and streamline the process as a hands-off automated approach. The design will also be able to be scaled up from seed nursery to an automated greenhouse.

Key project features and areas of focus:

- **Control** - An Android application that connects to the automated garden via MQTT to maintain various environmental controls.
- **Monitor** - The Android application will be used for Real-time feedback of the garden's various sensors to monitor the plants and environment.
- **Water wisely** - App controlled drip irrigation by schedule and/or moisture sensor. It's important to keep soil consistently moist, but avoid overwatering, which promotes diseases. Maintain consistent moisture. Once seedlings are growing, reduce watering so soil partially dries.
- **Keep soil warm** - Heat mat controller. Seeds need warm soil to germinate. They germinate slower, or not at all, in soils that are too cool. Most seeds will germinate at around 78°F.
- **Give seedlings enough light** - Timer for light source. Not enough light leads to leggy, tall seedlings that will struggle once transplanted outdoors. Ideally, seedlings need 14-16 hours of direct light per day for healthiest growth.
- **Circulate the air** - App/sensor fan control. Circulating air helps prevent disease and encourages the development of strong stems.
- **Inspect for disease** - RPi camera/monitoring with disease image recognition and app alert. The moist environment needed for the plants is also a good environment for the formation of powdery mildew.

Android capabilities:

The Android application that we will be developing for this project will primarily use it's web service capabilities to both be a monitor and a control for our smart greenhouse/nursery. The app will have access to sensors that provide reading for temperature, humidity, soil moisture, light, and a camera designed to detect powdery mildew. The application will provide settings to control the heat mat and lighting schedules, and set the soil moisture and humidity percentage to activate the water pump/fan respectively. This functionality will connect to a Raspberry Pi that is controlling the garden using the Paho MQTT client using the HiveMQ broker.

Raspberry Pi and other hardware:

The Raspberry Pi will be running a Python script to connect to and control the various functions of the garden and will utilize the Paho MQTT client library to connect to the Android device via HiveMQ. The other primary hardware tentatively used for this project is listed in the following table.

Hardware	**Description**
Raspberry Pi 3 B or later	SBC selected to control and monitor the garden
Adafruit AHT20	Temperature and humidity sensor, trigger to activate fan
Small fan	Fan turns on when temperature or humidity is too high
Soil Humidity Sensor	Check soil moisture, trigger to activate water pump
Small water pump & water pipe	Used to irrigate the soil trays with drip irrigation.
PCF8591 A/D Converter	Analog to digital converter for getting analog signals into the RPi
Photoresistor	Monitors light, trigger to turn on relay for lights
5V Relay Module	Used to turn on higher voltage devices
Heat Mat (120V)	Warm soil, activated by relay switch
Light(LED or fluorescent)(120V)	Maintain ~16/8 on/off light cycle, activated by relay switch
Raspberry Pi Camera	Used for imaging and tensorflow script to check for mildew

Table 1: Project Hardware

Other tools (besides android studio):

- Firmware: Python
- Development environment: VSCode, Pycharm
- MQTT Broker: HiveMQ
- Image analysis: Tensorflow
- Various other hardware for physical build

Design Approach

Requirements

Must:

1. Soil moisture sensor and water pump activation
2. Temperature/Humidity sensor with fan activation
3. Camera with tensorflow to monitor plants
4. Android application with added sensors and parameter settings for hardware

Should:

5. Add photoresistor to monitor luminosity
6. Add 5V relay switch
7. Code block for light and heat mat timer
8. LEDs to indicate when various hardware is/should be on

May:

9. Connect higher voltage lights and heat mat to 5V relay switch
10. Android: database to save data points, create modular controls for plant groupings
11. Additional sensors: water level sensor for supply,Servo for vent cover, Barometer, gas sensor

System Architecture

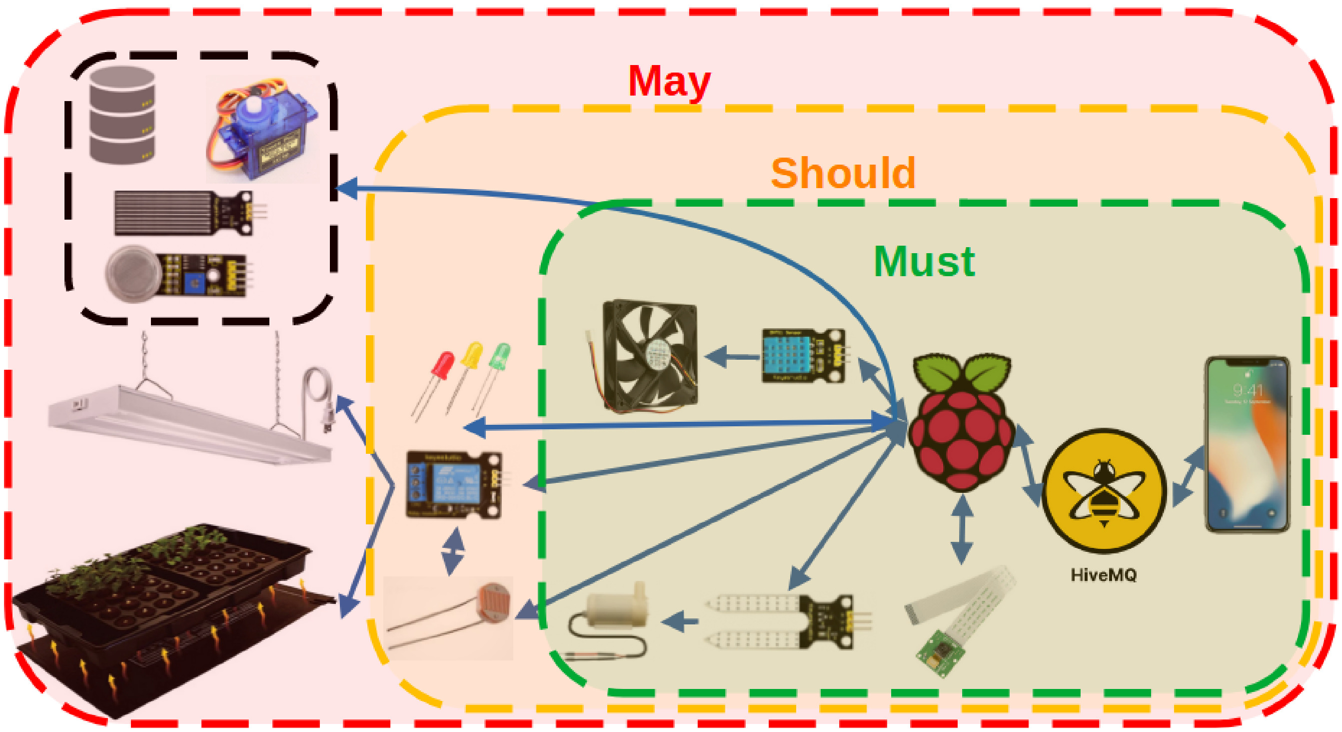

Figure 1: Diagram of hardware and requirement Levels

Project Delegation

David Craft - To handle the hardware build for the soil moisture sensor, water pump, temperature/ humidity sensor, fan and relay switch to control the lights and heat mat. David will also be working on the development of the controlling firmware to run on the Raspberry Pi.

Josh Blazek - Will work on the camera / tensorflow functionality that will run on the Raspberry Pi to detect powdery mildew and mold growth on the plants or soil. Josh will also work on the development of the android application to monitor and control the garden.

Additional functionality will be split out as tasks are completed.

Demonstrating Success

A growing tray (figure 2) with leafy greens will be used to demonstrate the success of the project over Zoom. Moisture levels will be adjusted on the Android application to a level that activates the drip irrigation system. The activation level of the heat mat, the lighting, and the humidity control will all be adjusted on the Android application to a level that activates those systems during the demonstration.

Baking Soda will be used as a stand-in for white mildew to test the image recognition and the alert system.

Figure 2: Grow Tray

Milestones

3/3/2022 - Project Proposal
3/6/2022 - Have functioning functioning hardware for 'Must' categories
3/9/2022 - Added functionality to hardware and app for 'Must' and 'Should' categories
3/10/2022 - Team meeting with Roy and Emily
3/12/2022 - Wrap up as much 'May' categories as possible
3/15/2022 - Finalize presentation, narrated video and demo preparations
3/17/2022 - Final deliverables due to Canvas and GitHub

Deliverables:

- Project proposal
- Narrated Video/Demo
- PDF of demo presentation slides
- Final Design Report
- Source Code from Github

Document Revision

02/27/2022 - Version 0.5 - Initial document
02/28/2022 - Version 1.0 - Final document

References

1. MQTT broker. The Public MQTT Broker by HiveMQ - Check out our MQTT Demo. (n.d.). Retrieved March 3, 2022, from https://www.hivemq.com/public-mqtt-broker/
2. Documentation; android developers. Android Developers. (n.d.). Retrieved March 3, 2022, from https://developer.android.com/docs