



Team E3 | Graduating Gardeners

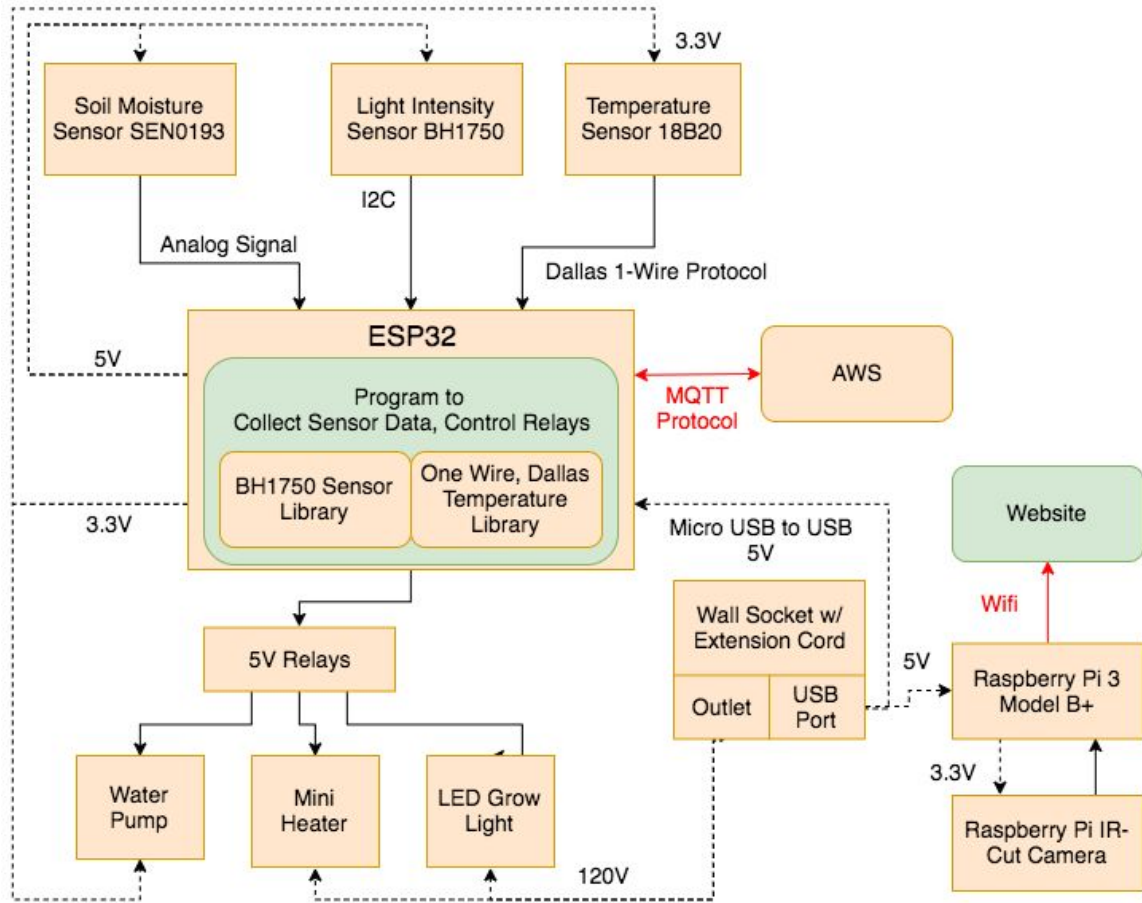
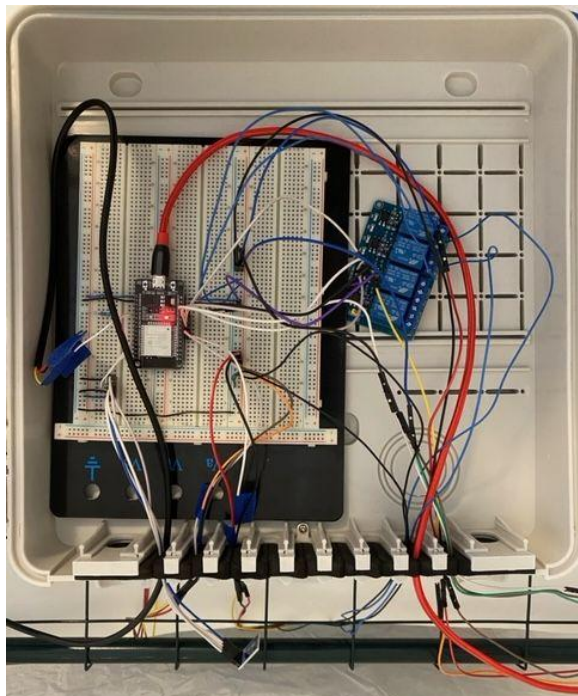
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Application Area

- ❖ Create a gardening environment at home
- ❖ Automate conditions
 - Lighting, heating, soil moisture
 - Specific to plant species
 - Option for manual control
- ❖ Detects growth status and defects
- ❖ Monitor plants live



Solution Approach / Block Diagram (Hardware)



KEY

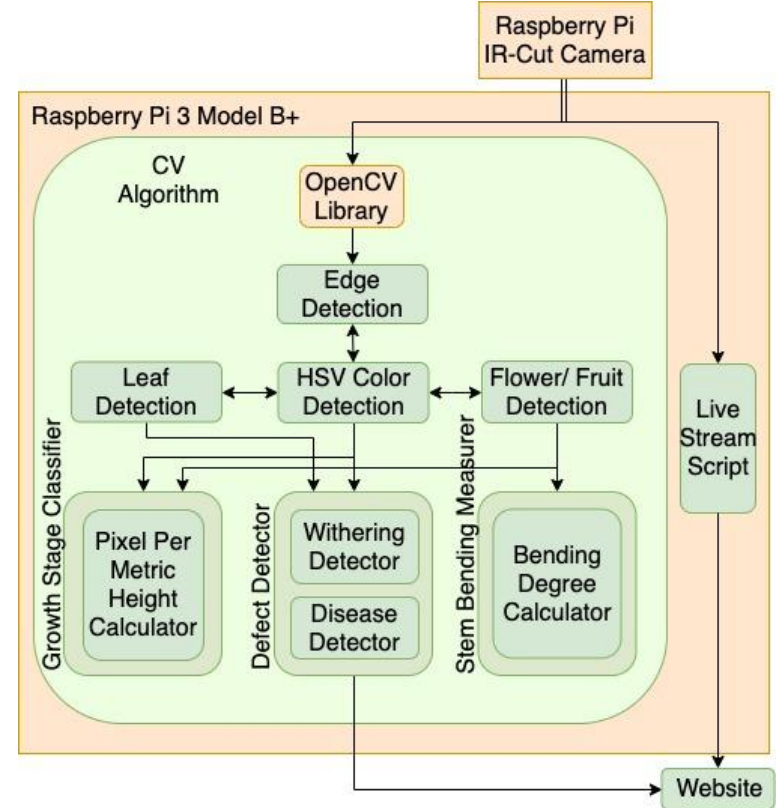
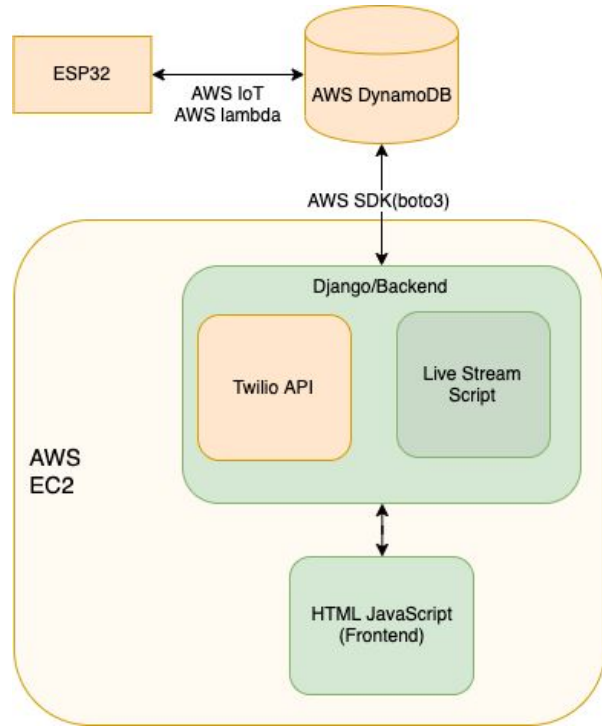
Hardware

Software

Off the Shelf

Newly Designed

Solution Approach / Block Diagram (Web app/CV)



KEY

Hardware

Software

Off the Shelf

Newly Designed

Complete Solution (Hardware & Web App.)

- ❖ Change temperature unit between °F and °C
- ❖ Show current information of the greenhouse and enable user to set preferred values
- ❖ Greenhouse system will adjust conditions to reflect user's settings

Hello, demotest [Logout](#)

°c

📌 Your Greenhouse Info

🌡️ 21 °c

💧 3,0 %

💡 OFF

📌 User Settings

Temperature 25°c

Soil Moisture 1 64%

Soil Moisture 2 42%

Light ▾

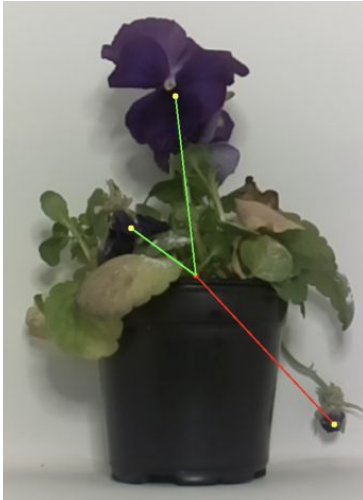
Is your greenhouse placed indoor or outdoor? ▾

✔ Save Changes

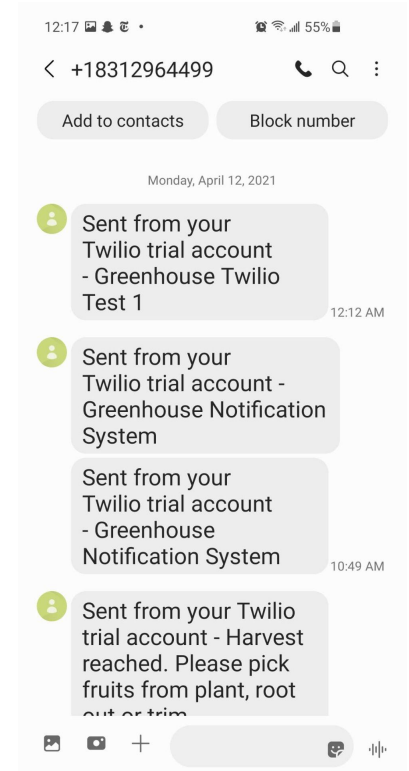


Complete Solution (CV)

- ❖ Live stream monitoring on website
- ❖ Notifications on plant status sent to/ viewable on:
 - SMS
 - Website



- ❖ Growth stage classifier
 - Germination, Young Plant, Fruiting/ Flowering, Harvest
- ❖ Disease detection
 - White and dark spotting
 - Withering
- ❖ Stem Bending
 - Angle between fruit/ flower and plant center



Testing Results (Hardware)

Functionality	Testing Strategy	Results
Heating	Current greenhouse temperature of 74°F, set goal temperature to 80°F	Reach 84°F in 10 minutes, heater turns off after reaching 84°F
Watering	Set target soil moisture percentage higher and lower than current value.	Water pump turns on when target is set higher, stays off when target is lower
Data transmission (ESP32 to DynamoDB)	Send data from ESP32 to DynamoDB. Calculate difference between timestamps.	Average 1.8s
Data transmission (ESP32 to Web App.)	Send data from Web App. to Hardware. Calculate difference between timestamps.	0.2s~12.3s depending on wifi speed

Testing Results (CV)

Functionality	Testing Strategy	Results
Growth Stage Classifier	Analyze pea shoots sprouting -> maturity (15 images) Analyze different flower plants in different stages (5 images)	Error Rate: 10% Avg. Highest Height Difference: .467 cm
Withering Detection	Replace patches of wet pea shoot soil with dry soil (10 images) Analyze flower plants w/ mixed healthy, withered leaves (10 images)	False pos. = 9%, False neg. = 7% False pos. = 7%, False neg. = 4%
Disease Detection	Simulate disease on plants (20 images): -White spotting -Dark spotting	False pos. = 2%, False neg. = 3% False pos. = 15%, False neg. = 9%
Vine Bending Measurer	Angle between y-axis and line from plant center to flowers (4 plants, 5 images each)	Error Rate: 9% Avg. Degree Difference: 5°

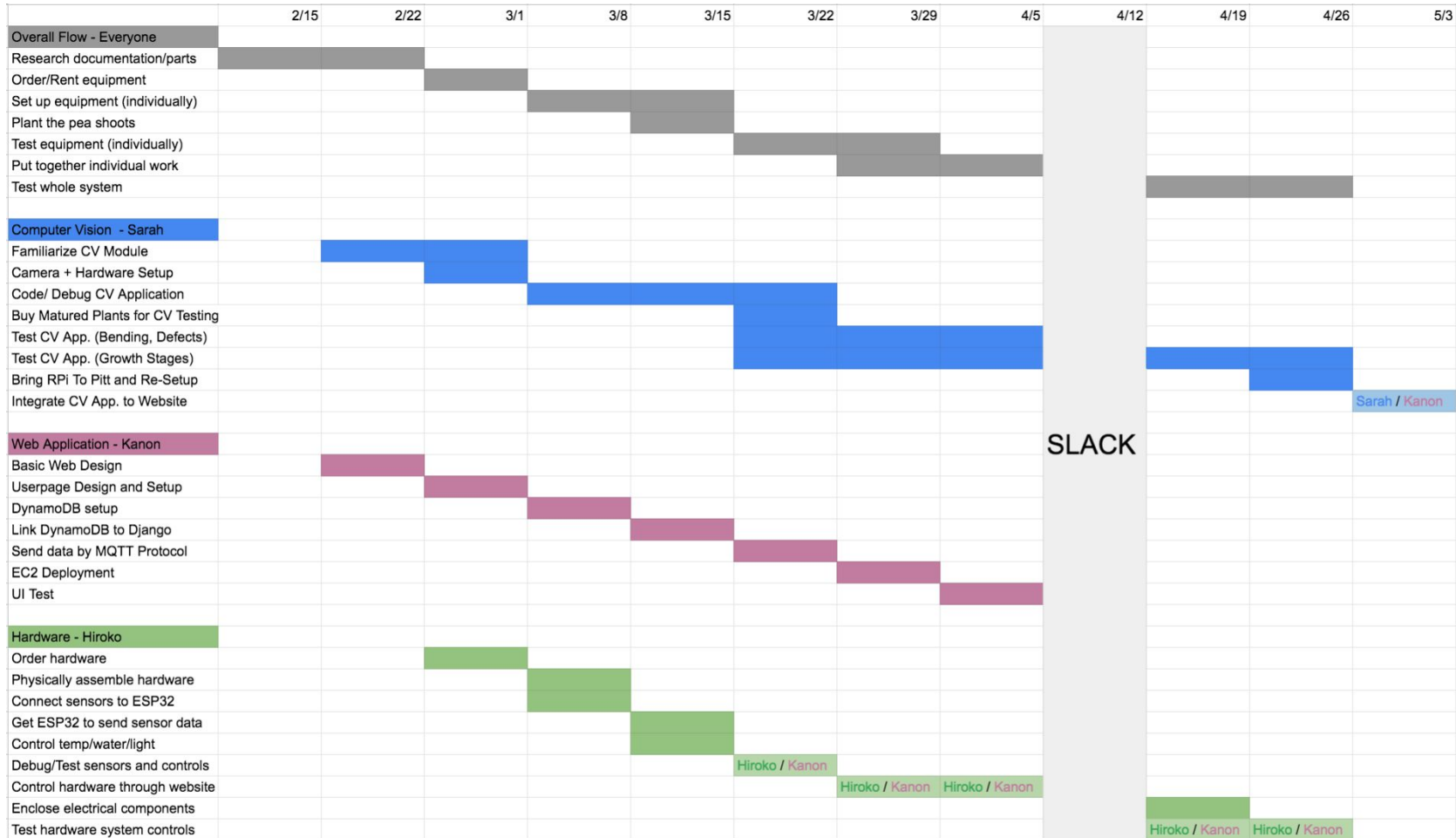
Testing Results (Web App.)

Functionality	Testing Strategy	Metrics
Video Streaming	10x: (Time object appears in stream) - (Time placing object in frame)	Average latency = 8.769 sec.
Web UI	Conduct a survey about the UI for 10 random people Conduct second survey with the same 10 users after the improvement on the UI.	6/10 people found it confusing 10/10 people found it easy to navigate

Design Trade-Offs

- ❖ Plant capacity of 1
 - Diversity of plants limited
 - More distance between camera and plant for CV analysis
- ❖ Find center of plant instead of stem detection
 - Ideally want CV to distinguish between leaves and stem, inefficient
 - More accurate results
- ❖ Use both ESP32 and RPi
 - Everything could be done on one board
 - Night vision camera only available for RPi
 - Not all team members in Pittsburgh, work can be done in parallel
- ❖ Monitor sensor values every 10 minutes
 - Too many data transmissions + data analysis if we constantly monitor

Project Management



Work Remaining

- ❖ Web Application
 - Integrate live video streaming
 - Light scheduling
- ❖ CV
 - Turn CV analysis off during night mode
 - Script for automatic CV analysis when RPi boots
- ❖ Final Video / Final Poster
- ❖ Final Report
 - Add testing results and ethical issues

