

# 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)**







## Solution Approach / Block Diagram (Web app/CV)





#### **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 <u>Logout</u>
0
Y Your Greenhouse Info
<b>∂</b> 21 °c
♦ 3, 0 %
€ OFF
A User Settings
Temperature 25°c
Soil Moisture 1 ———— 64%
Soil Moisture 2 ——— 42%
Light OFF 🗸
Is your greenhouse placed indoor or outdoor? indoor
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

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#### **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	6/10 people found it confusing 10/10 people found it easy to
	Conduct second survey with the same 10 users after the improvement on the UI.	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**

	2/15	2/22	3/1	3/8	3/15	3/22 3/2	9 4/5	5 4/12	2 4/19	9 4/26	5/3
Overall Flow - Everyone											
Research documentation/parts											
Order/Rent equipment											
Set up equipment (individually)											
Plant the pea shoots											
Test equipment (individually)											
Put together individual work											
Test whole system											
Computer Vision - Sarah											
Familiarize CV Module											
Camera + Hardware Setup											
Code/ Debug CV Application											
Buy Matured Plants for CV Testing											
Test CV App. (Bending, Defects)											
Test CV App. (Growth Stages)											
Bring RPi To Pitt and Re-Setup											
Integrate CV App. to Website											Sarah / Kanon
Web Application - Kanon								SLACK			
Basic Web Design											
Userpage Design and Setup											
DynamoDB setup											
Link DynamoDB to Django											
Send data by MQTT Protocol											
EC2 Deployment											
UI Test											
Hardware - Hiroko											
Order hardware											
Physically assemble hardware											
Connect sensors to ESP32											
Get ESP32 to send sensor data											
Control temp/water/light											
Debug/Test sensors and controls					Hiroko / Kai	on					
Control hardware through website						Hiroko / Kanon	Hiroko / Kanon				
Enclose electrical components											
Test hardware system controls									Hiroko / Kanon	Hiroko / Kanon	

## **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

