Dwight Look College of ENGINEERING
TEXAS A&M UNIVERSITY

# ECEN 404 Final Presentation
# Team 2: Robotic Sorting System

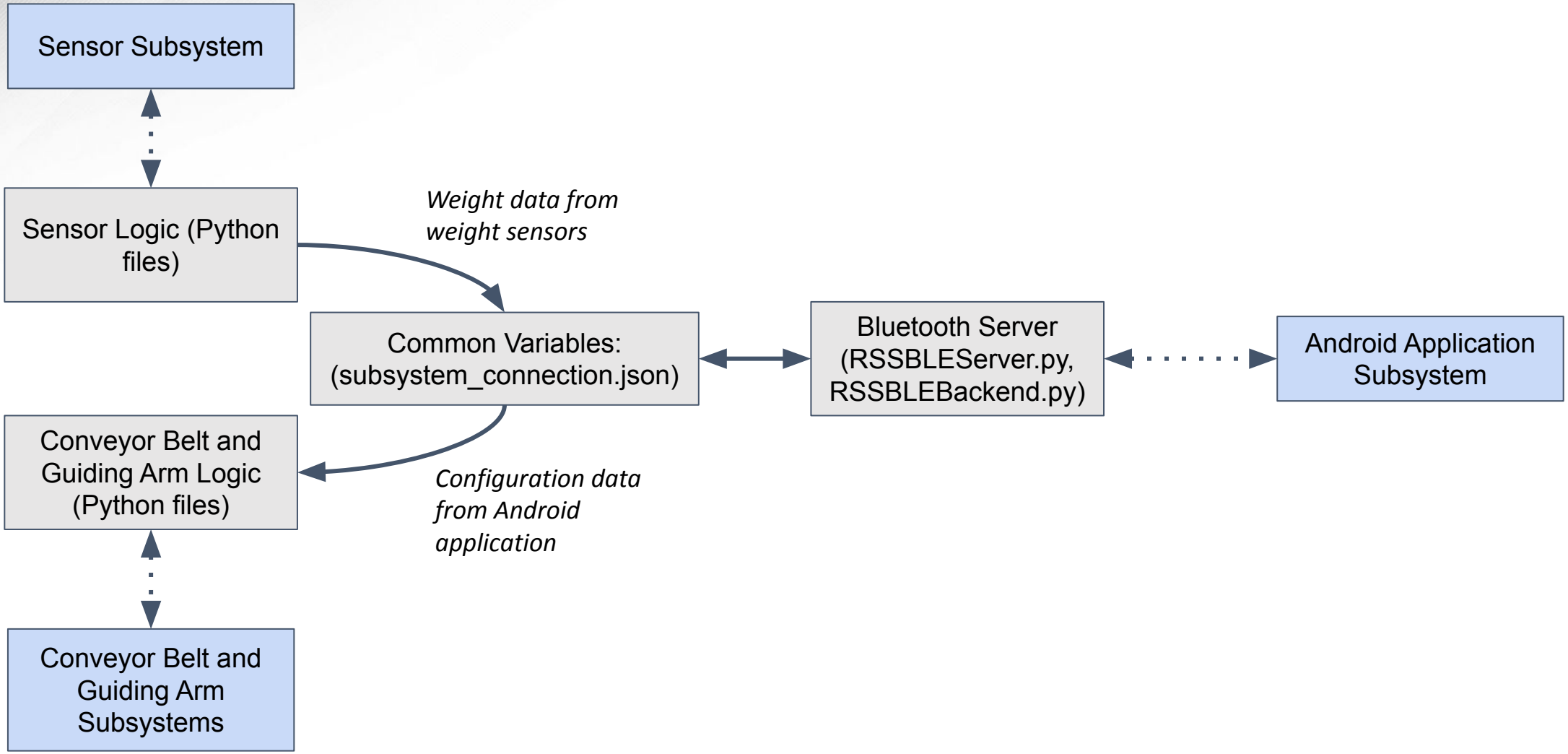
Pace Dominy, Joseph Miller, Lam Tran
TA: Swarnabha Roy
Sponsor: Dalton Cyr

# Problem Overview

Sorting fruit by hand can be tedious and expensive.

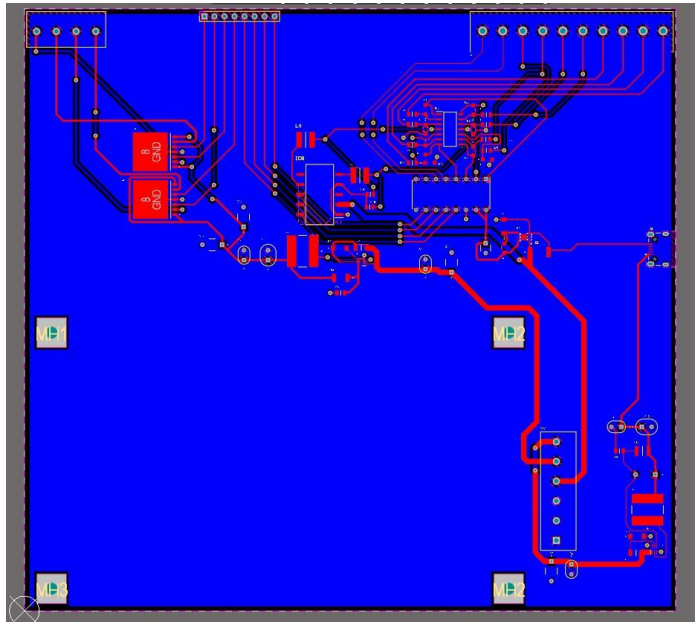
The Robotic Sorting System aims to solve these problems by automating the sorting process and freeing up time and manpower for small farmers.

# Integrated System Diagram

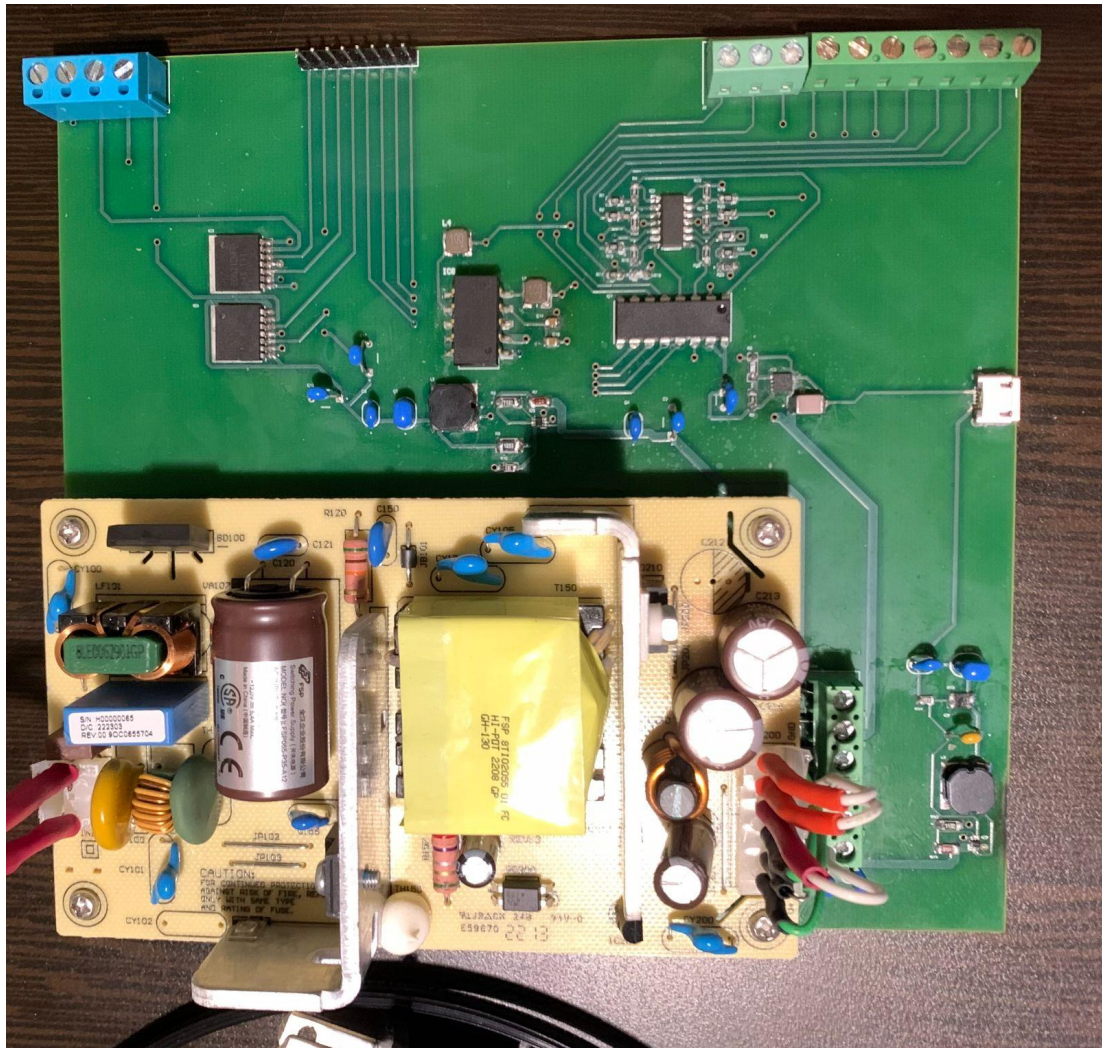


# Engineering Design Accomplishments – Pace Dominy

- Designed and built power supply to power entire system
  - Motor controllers, Raspberry Pi, DAC, and op-amp IC for load cells
- Designed and built conveyor belt and guiding arms



PCB Design Altium (Left)
Finished PCB (Right)



# Engineering Design Accomplishments – Pace Dominy

| | Input Voltage | Expected Output | Actual Output | Error |
|---|---|---|---|---|
| Vcc (Motor Controller Power Supply) | 12 V (12.135) | 4 V | Max: 4.06 V<br>Min: 3.915 V | Avg: 3.9875 V<br>Error: 0.3125 % |
| Raspberry Pi Power | 12 V (12.135) | 5 V | Max: 5.142 V<br>Min: 4.989 V | Avg: 5.0655<br>Error: 1.31 % |
| ADC Power | 12 V (12.135) | 3.3 V | Max: 3.316 V<br>Min: 3.284 V | Avg: 3.3 V<br>Error: 0 % |
| Op Amp Power (Positive, Negative) | 12 V (12.135) | ±5 V | Max: 5.567 V, -5.433 V<br>Min: 5.406 V, -5.584 V | Avg: 5.487 V, -5.515 V<br>Error: 9.73 %, 10.27 % |

## Validation Results

| Item | Met |
|---|---|
| PCB Output Voltages at Acceptable Range | Yes |
| Conveyor Belt/Guiding Arm Move to Correct Positions Based Off of Current and Next Location | Yes |
| Conveyor Belt/Guiding Arm Move At Separate Times For Correct Amount of Time | Yes |

# Engineering Design Accomplishments – Pace Dominy

- Challenge: Designed PCB wrong due to problems with importing symbols from third party software
  - Solution: “Blue wired” pins to correct traces
- Challenge: Debug a PCB with minimal to no experience with lab equipment, i.e. oscilloscope, due to COVID (only had experience with AD2 prior to capstone)
  - Solution: Online videos explaining proper use of lab equipment and why, for example, the oscilloscope has a 10:1 and 1:1 setting for the oscilloscope probe.
- Challenge: Properly tensioning a conveyor belt without any prior experience building a conveyor belt before and having zero Mechanical Engineering Experience
  - Solution: Tried multiple solutions and ultimately ended up putting a cardboard platform between the belt and all but one of the rollers in order to prevent lemon from getting stuck between the rollers.

# Engineering Design Accomplishments – Joseph Miller

*Database Interactions - Challenges and Solutions*

Challenge: Reading updated values from a .py file without restarting applications

- Solution: Use a .json database instead, which is far better supported for this purpose

Challenge: Expanding the system to support additional categories of information as needed

- Solutions:
  - Bluetooth server: Add another number to the array used for the configuration and weight characteristics
  - Database: Simply add another key:value pair
  - Android app: Update the ViewModel handling the Bluetooth information to handle a wider array properly and without errors

Challenge: Expanding the system to support machine learning sorting

- Solution: The infrastructure for this exists in the Android app and can easily be added to the database

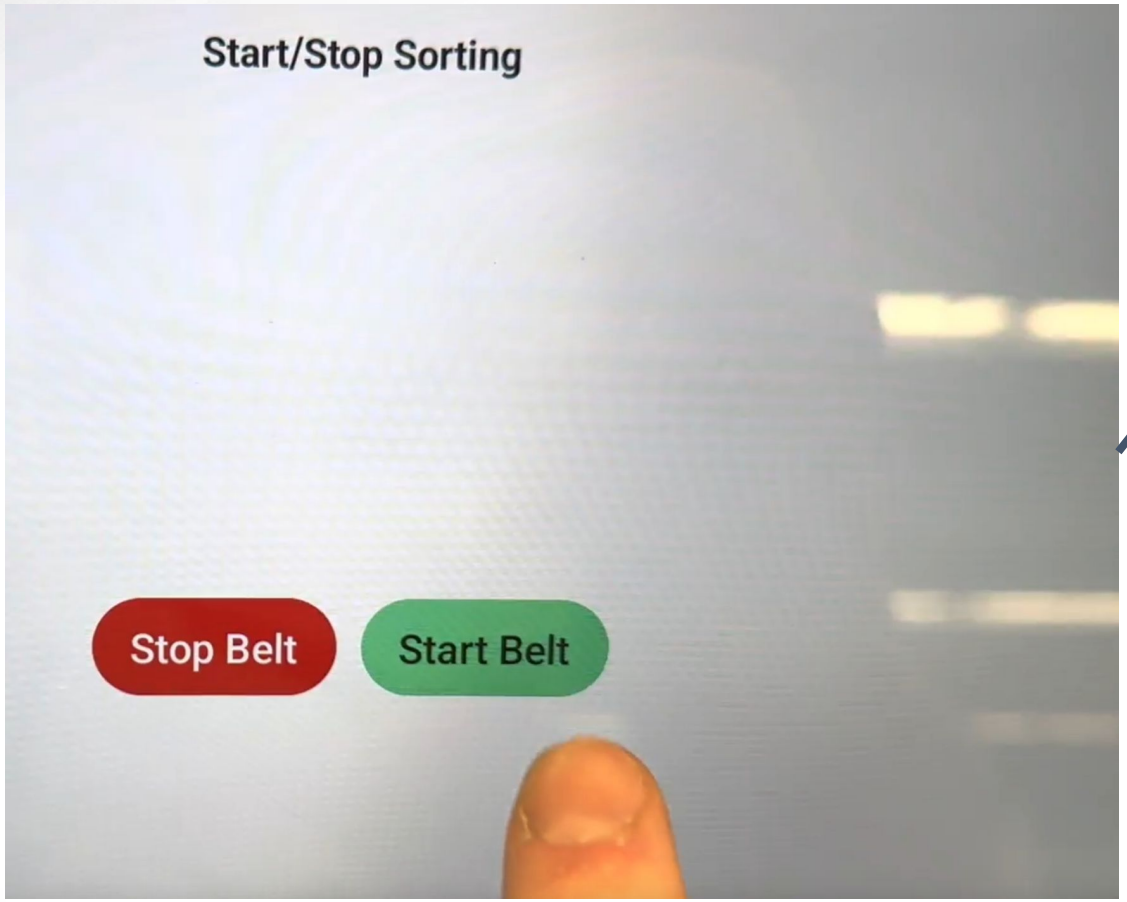
# Engineering Design Accomplishments – Joseph Miller

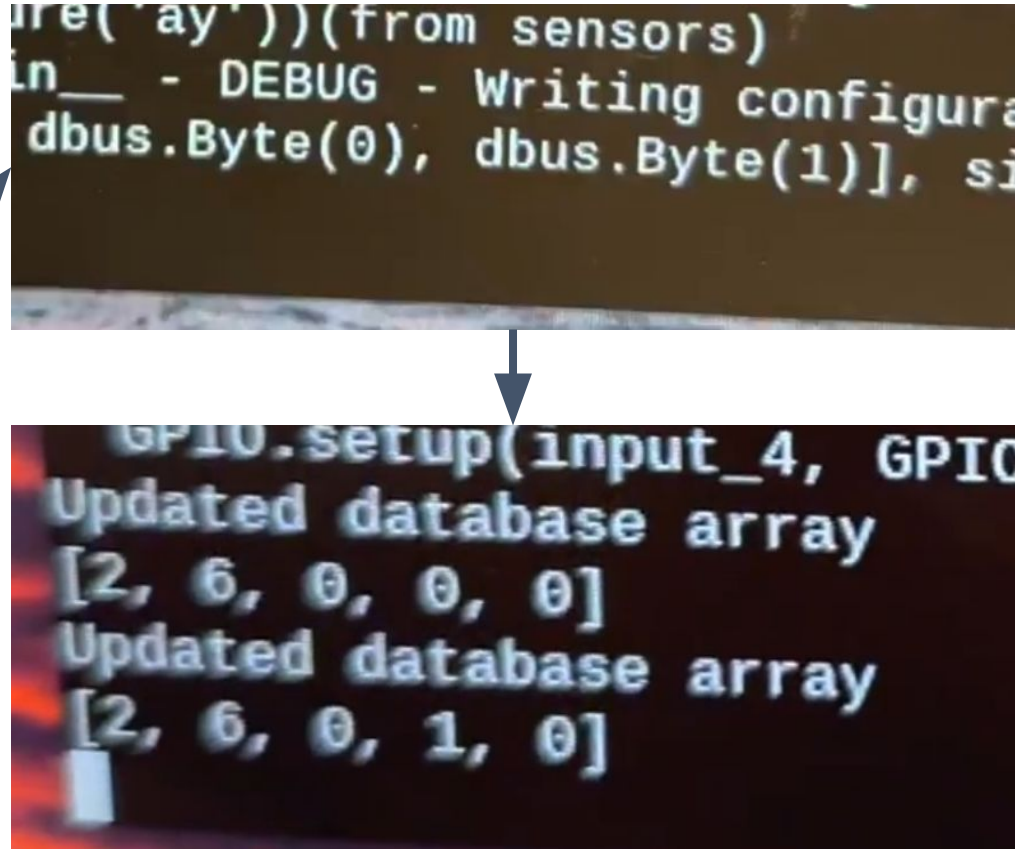
*Database Interactions in Detail*

| System Component | Interaction with database |
|---|---|
| Android Application (via Bluetooth server) | ● Writes user-specified configuration data (including sort start/stop)<br>● Reads weight from load cells, current configuration, and characteristic of current fruit<br>○ Machine learning sort option exists: needs machine learning output from sensors |
| Conveyor Belt | ● Starts and stops sorting based on belt control bit<br>○ Still need to work on smooth sorting implementation |
| Guiding Arms | ● Given a certain fruit characteristic, the robotic arms move to the correct bin |
| Sensors | ● Writes the current weight and the characteristic to the server<br>○ Still working on noise in load cells |

# Engineering Design Accomplishments – Joseph Miller

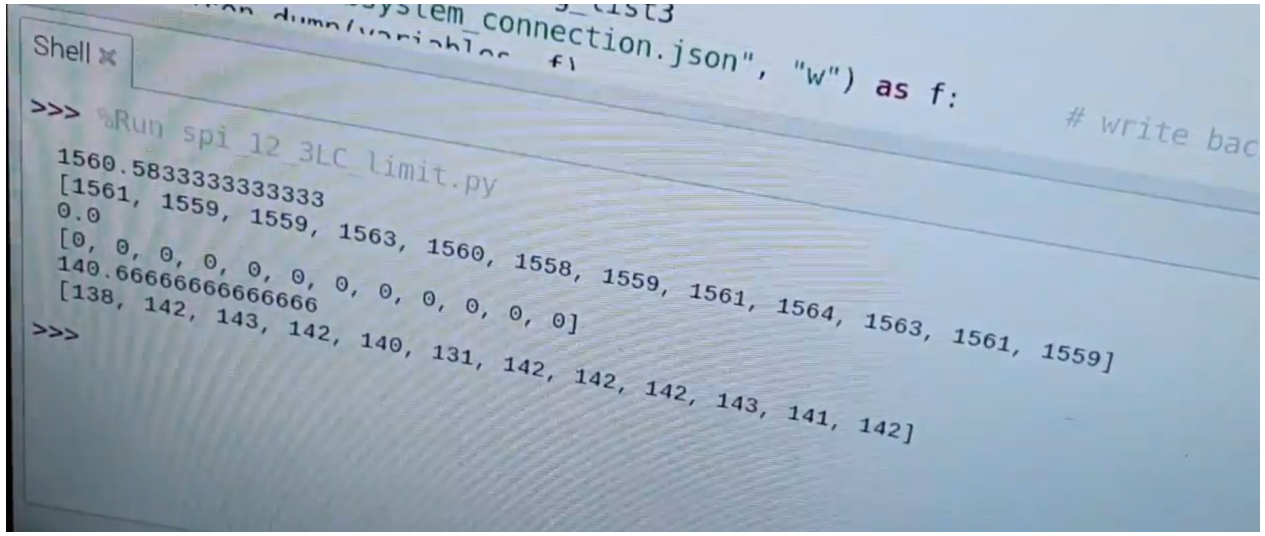
*Example of Database Interactions: Application, BLE Server, Conveyor Belt*

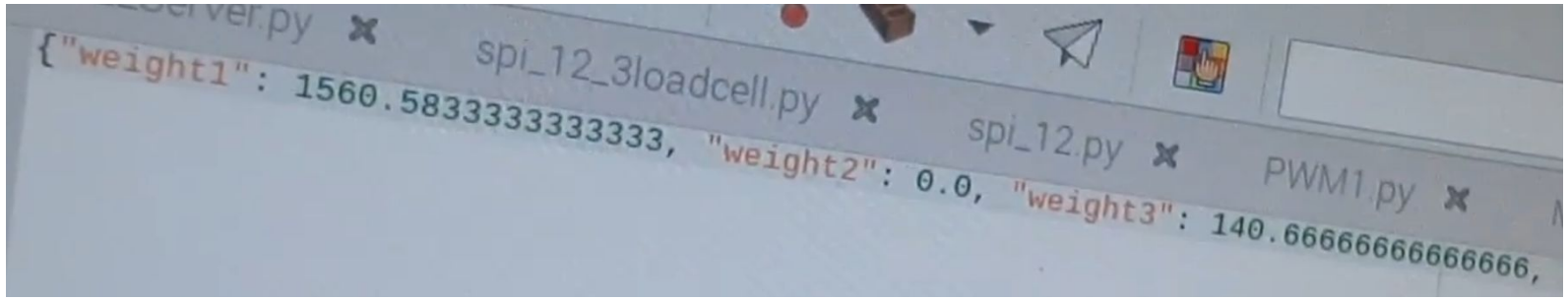


# Engineering Design Accomplishments – Joseph Miller

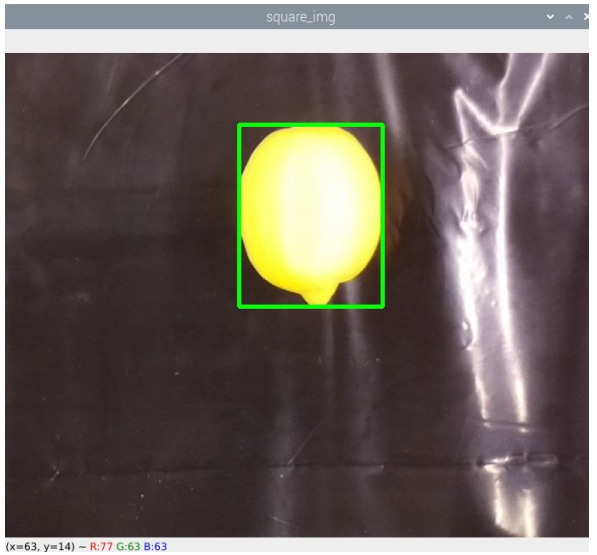
*Example of Database Interactions: Weight Sensors*



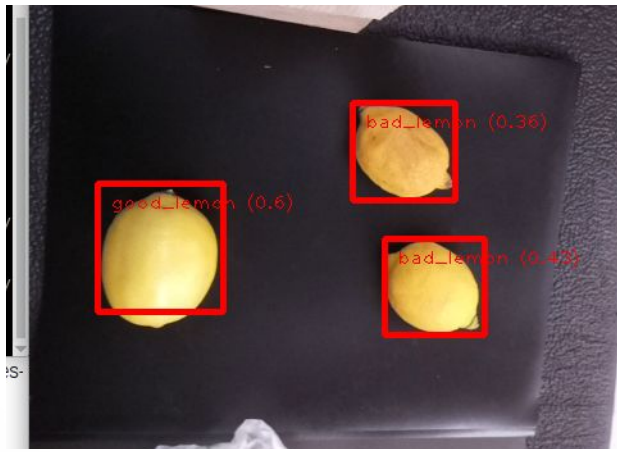



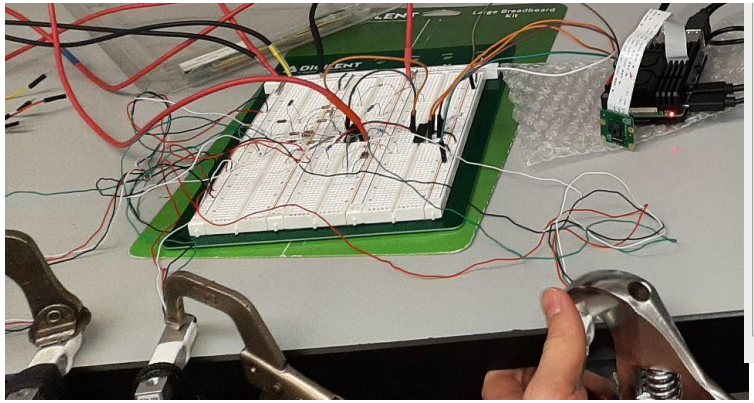
# Engineering Design Accomplishments – Lam Tran

- Designed a color/size sensor
  - Can detect the color of the object with its hue values
  - Can measure the size of the object
  - From an image taken from the Raspberry Pi Camera
- Designed a weight sensor
  - Can measure the weights of three bins
  - From three load cells connected to the Raspberry Pi
- Trained Machine Learning Model
  - Determine good lemons and bad lemons




```
Shell
>>> %Run integrate_w_belt.py
  29.90987689461325
  30.0
  YELLOW
  height by pixels:  214
  width by pixels:  169
  height by inch:  2.876437624145659
  width by inch:  2.271579245236525
  number of stuff on the belt is: 1
  seem like there is no error
  sort by size
```



```
Shell
load cell 3 ADC volt:  0.9796874999999999 V
list of prev 12 data:  [1216, 1376, 1415, 1365, 1484, 1466, 0, 0, 0, 0, 0, 0]
the mean of the list:  693.5
For load cell 1
load cell 1 ADC volt:  0.6775634765624999 V
list of prev 12 data:  [841, 838, 835, 838, 838, 837, 833, 833, 846, 833, 833, 837]
the mean of the list:  836.8333333333334
For load cell 2
load cell 2 ADC volt:  0.201416015625 V
list of prev 12 data:  [250, 238, 250, 249, 248, 250, 250, 244, 240, 241, 245, 243]
the mean of the list:  245.66666666666666
For load cell 3
load cell 3 ADC volt:  0.9917724609374999 V
list of prev 12 data:  [1231, 1216, 1376, 1415, 1365, 1484, 1466, 0, 0, 0, 0, 0]
the mean of the list:  796.0833333333334
```

# Engineering Design Accomplishments – Lam Tran

| Item | spec | Min | Max |
|---|---|---|---|
| Weight Sensor Analog to Digital output | int | 0 | 4095 |
| Hue Range | int | 0 | 180 |

| Item | Met |
|---|---|
| Stable Weight Sensor reading | Yes |
| Color/Size Sensor Error detection | Yes |
| Image Noise filtering | Yes |
| Detecting Objects | Yes |
| Linear relationship of weight load and ADC output | Yes |
| Output color based on Hue range | Yes |
| Convert # of pixels to inches | Yes |

# Engineering Design Accomplishments – Lam Tran

- Challenge: Third load cell has noisy reading with PCB integrated
- Solution: Normalize the reading by subtracting by the no load output
- Challenge: Load cell data integration with Bluetooth due to only accepting integer value from 0 to 255
- Solution: Convert the 0 - 4095 reading to 0 - 255 reading
- Challenge: ML model having trouble detecting bad lemon under bright lighting
- Solution: Train with data of lemons with uneven and bright lighting

# Integrated System Results

https://youtube.com/shorts/lhHutrBqpQY?feature=share

# Conclusions

**Changes from Project Requirements**

- Focuses on lemons, particularly for sensing purposes
- Does not image all sides of fruit
- Exceeded initial $300 budget
- Temperature testing not practical

**Current project status**

- Still perfecting machine learning model
- Adapting belt to allow continuous sorting without user operation
- Solving noise issues with load cells
- Bluetooth is fully functional, but a bit slow to connect (~10-20s)

# Thank you!