
Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

# Team 5: 3D Occluded Object Detection System

**Team members:**
Evan Kolin
Tony Jeong
Hannah Hillhouse
Samiha Elahi

**Sponsor:**
Kevin Nowka

# Project Summary

**Problem:**

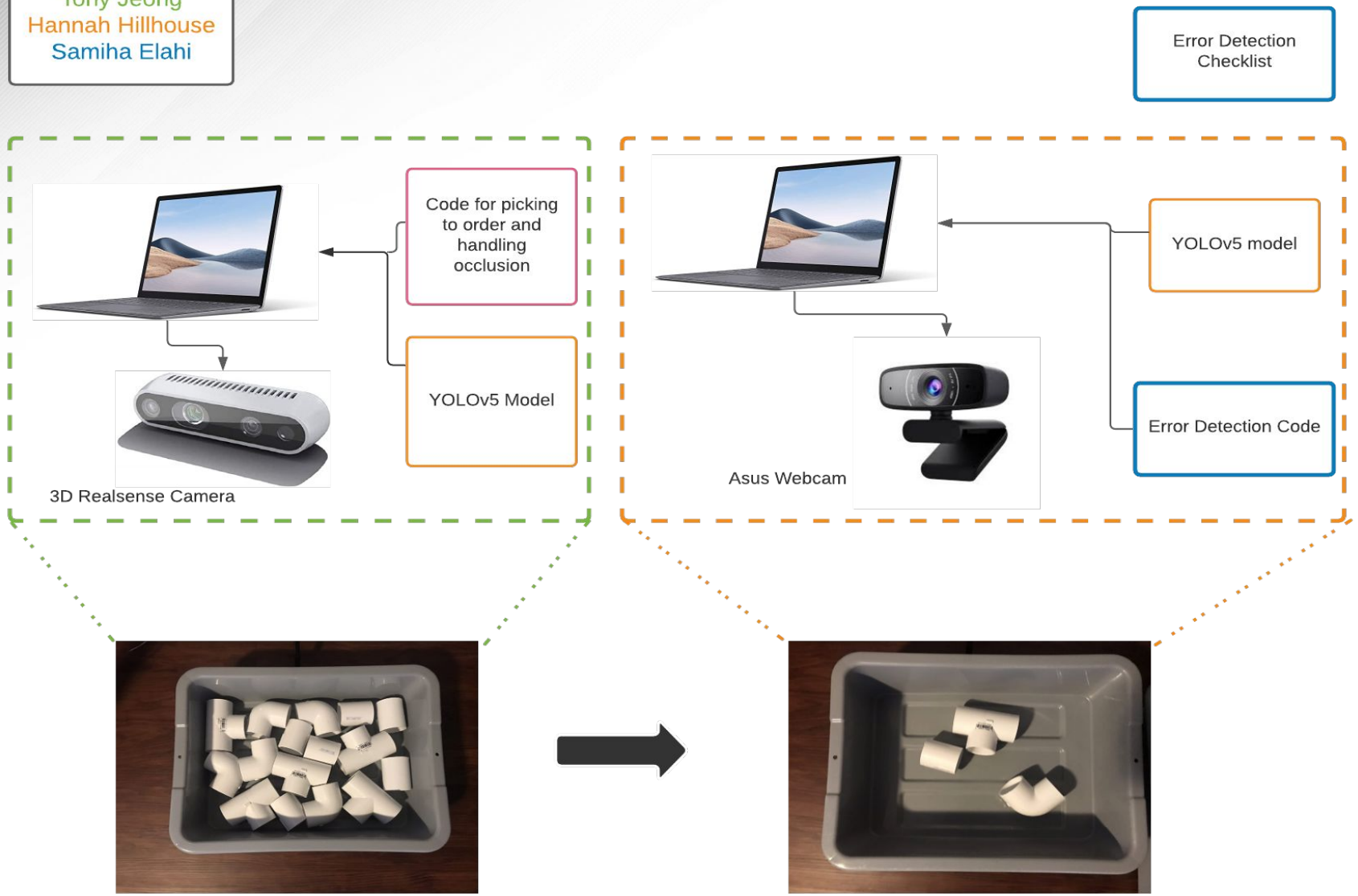
Manufacturers are using people to pick and place parts into bins for further use. This is not only costly to the company but also not time efficient and results in a very cluttered workspace.

**Solution:**

We will create an object detection system in which will localize and classify objects within the parts bins and pick and place them into their corresponding bins for further use. We have two cameras, one to look into the bin with all the parts, and one to look at the bin with already picked parts. Both cameras are attached to a raspberry pi that holds the object classification model and the object localization code.

Team Subsytem Chart
Evan Kolin
Tony Jeong
Hannah Hillhouse
Samiha Elahi

# Integrated Project Diagram



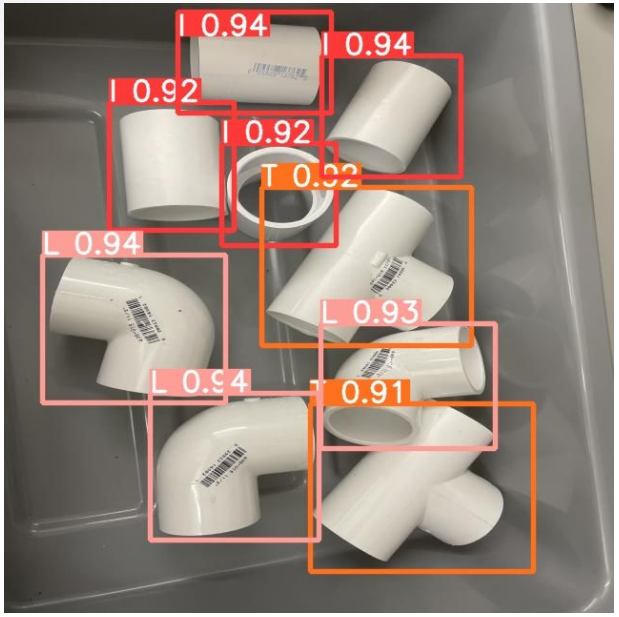
# Engineering Design Accomplishments
## Hannah Hillhouse

- Labeled 400 image dataset to train a functioning model
- Tested and validated the trained model
- Created a functioning object detection and localization system using the created model on personal computer


# Engineering Design Accomplishments

## Hannah Hillhouse

- Testing was done on over 100 images and below I will break it down into 10 image sections

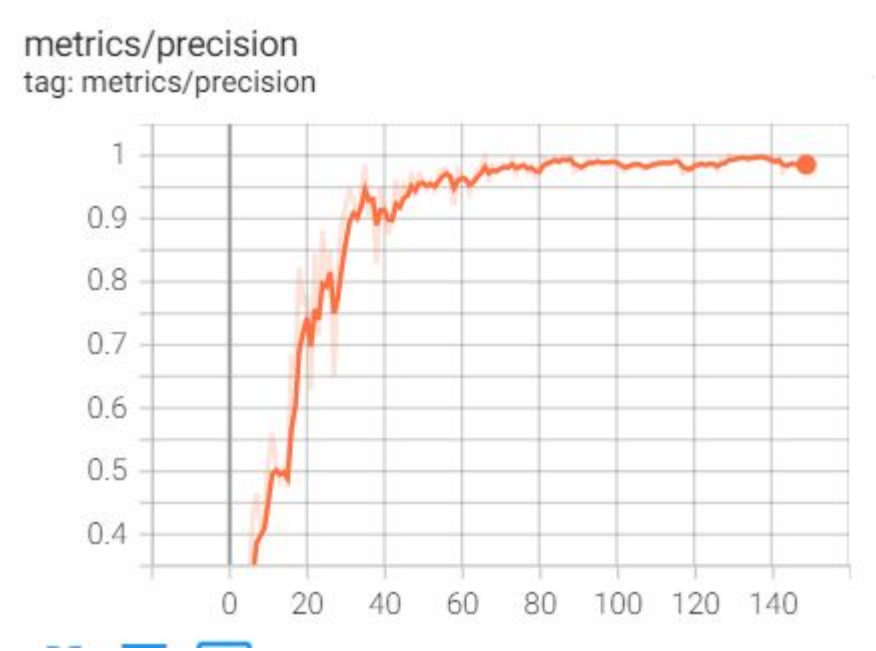



| Detected an object | Accurately labeled objects | Accurately labeled occluded objects | time it took to detect and label objects in image |
|---|---|---|---|
| 10 out of every 10 images test | 8 out of every 10 images tested | 4 out of every 10 images tested | < 0.5 sec |

image 16/46 /content/datasets/Update_model-1/test/images/IMG_0968_JPG.rf.c8ec8fa8a69d13be30f59a1b9720209a.jpg: 416x416 4 Is, 3 Ls, 2 Ts, Done. (0.025s)

# Engineering Design Accomplishments

Hannah Hillhouse




- Validation precision graph for trained model shows precision at 140 epochs reaching 98%

**Problems encountered**

- program compatibility and solved with using anaconda jupyter notebook in a virtual environment on personal computer
- Downloading opencv on the pi so we can move everything to the pi is currently still ongoing. I am getting access to a raspberry pi 4 so see if it will solve issues

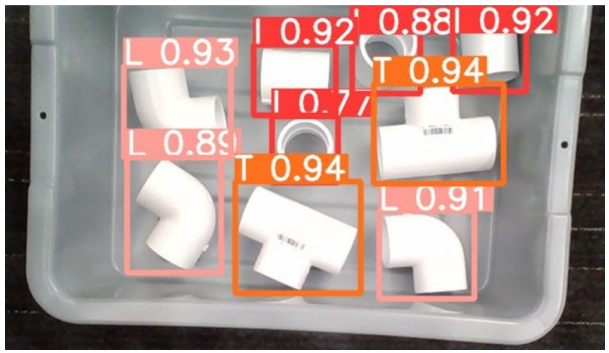
**Validation**

- I have included my models precision graph
- For object detection system most of my validation is included in the error detection slides coming

# Engineering Design Accomplishments

## Samiha Elahi

- Integrated the error detection and the 2D camera subsystem
- Labeled 100 image dataset of hidden or occluded parts to check if the model can still successfully detect the parts on those images.
- Created a code that asks the user to input the total number of parts needed to meet the order requirement and then checks the total number of actual parts in the image to check  if we have a missing or an extra part.




```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:1] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 4 Is, 3 Ls, 2 Ts, Done. (0.263s)
Enter the number of I shaped PVCs: 7
Enter the number of L shaped PVCs: 1
Enter the number of T shaped PVCs: 2
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 4 Is, 3 Ls, 2 Ts, Done. (0.343s)
{'I': 4, 'L': 3, 'T': 2}
Error! 3 I is/are missing
Error! 2 L is/are excess
 3 I added to the CURRENT BIN from the PARTS BIN
 2 L removed from the CURRENT BIN to the PARTS BIN
PS C:\Users\hanna\yolov5-final\yolov5>
```

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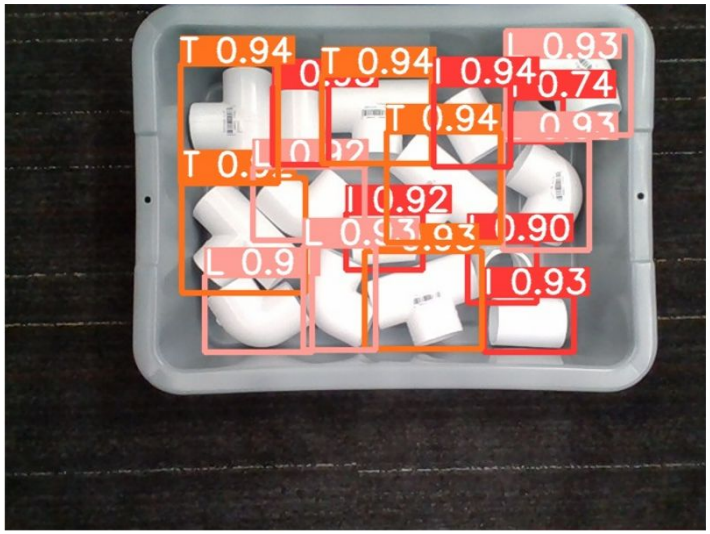
# Engineering Design Accomplishments

## Samiha Elahi

When the users input is the same as the model's output:

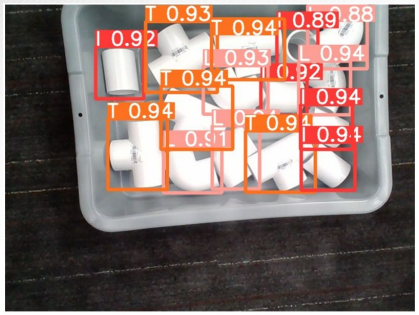



```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:0] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.298s)
Enter the number of I shaped PVCs: 6
Enter the number of L shaped PVCs: 5
Enter the number of T shaped PVCs: 5
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.372s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area


Performing image processing again


YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.371s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area
```

# Engineering Design Accomplishments

## Samiha Elahi

Before:




```
Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 5 Is, 5 Ls, 5 Ts, Done. (0.244s)
Enter the number of I shaped PVCs: 6
Enter the number of L shaped PVCs: 5
Enter the number of T shaped PVCs: 5
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 5 Is, 5 Ls, 5 Ts, Done. (0.231s)
{'I': 5, 'L': 5, 'T': 5}
Error! 1 I is/are missing
 1 I added to the CURRENT BIN from the PARTS BIN
```

After rearranging the parts:


```
Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.291s)
Enter the number of I shaped PVCs: 6
Enter the number of L shaped PVCs: 5
Enter the number of T shaped PVCs: 5
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.278s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area


Performing image processing again


YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.246s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area
```

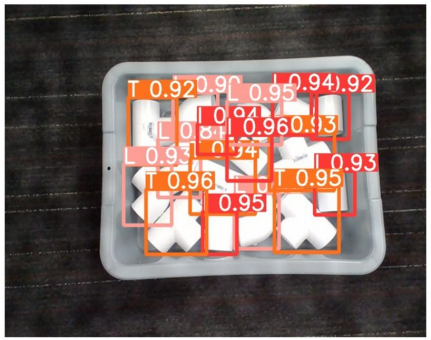
# Engineering Design Accomplishments

## Samiha Elahi

Before:


```
Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 7 Is, 5 Ls, 6 Ts, Done. (0.226s)
Enter the number of I shaped PVCs: 6
Enter the number of L shaped PVCs: 5
Enter the number of T shaped PVCs: 5
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 7 Is, 5 Ls, 6 Ts, Done. (0.344s)
('I': 7, 'L': 5, 'T': 6)
Error! 1 I is/are excess
Error! 1 T is/are excess
 1 I removed from the CURRENT BIN to the PARTS BIN
 1 T removed from the CURRENT BIN to the PARTS BIN
```

After shaking the bin:

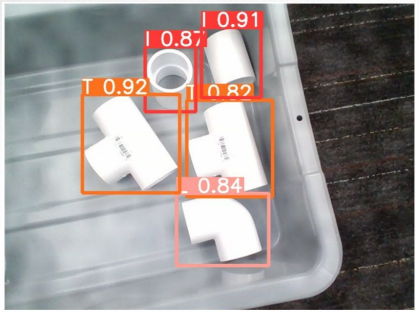



```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:0] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.239s)
Enter the number of I shaped PVCs: 6
Enter the number of L shaped PVCs: 5
Enter the number of T shaped PVCs: 5
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.339s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area


Performing image processing again


YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 6 Is, 5 Ls, 5 Ts, Done. (0.351s)
{'I': 6, 'L': 5, 'T': 5}
Entire order is here, move to the staging area
PS C:\Users\hanna\yolov5-final\yolov5>
```

# Engineering Design Accomplishments

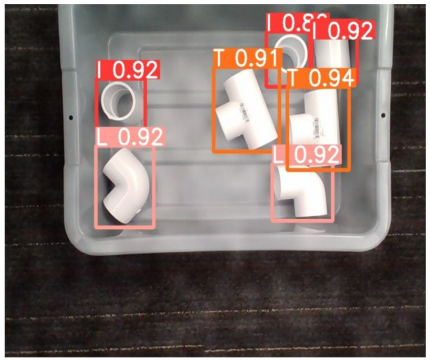
## Samiha Elahi

Before:




```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:0] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 2 Is, 1 L, 2 Ts, Done. (0.311s)
Enter the number of I shaped PVCs: 3
Enter the number of L shaped PVCs: 2
Enter the number of T shaped PVCs: 2
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 2 Is, 1 L, 2 Ts, Done. (0.340s)
{'I': 2, 'L': 1, 'T': 2}
Error! 1 I is/are missing
Error! 1 L is/are missing
 1 I added to the CURRENT BIN from the PARTS BIN
 1 L added to the CURRENT BIN from the PARTS BIN
PS C:\Users\hanna\yolov5-final\yolov5>
```

After changing the camera angle:




```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:1] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 3 Is, 2 Ls, 2 Ts, Done. (0.228s)
Enter the number of I shaped PVCs: 3
Enter the number of L shaped PVCs: 2
Enter the number of T shaped PVCs: 2
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 3 Is, 2 Ls, 2 Ts, Done. (0.358s)
{'I': 3, 'L': 2, 'T': 2}
Entire order is here, move to the staging area


Performing image processing again


YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 3 Is, 2 Ls, 2 Ts, Done. (0.345s)
{'I': 3, 'L': 2, 'T': 2}
Entire order is here, move to the staging area
PS C:\Users\hanna\yolov5-final\yolov5>
```

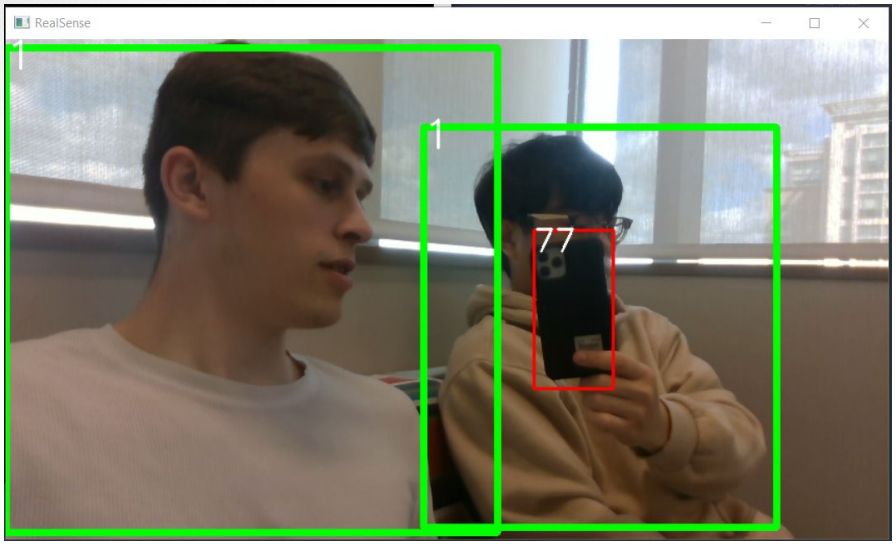
# Engineering Design Accomplishments

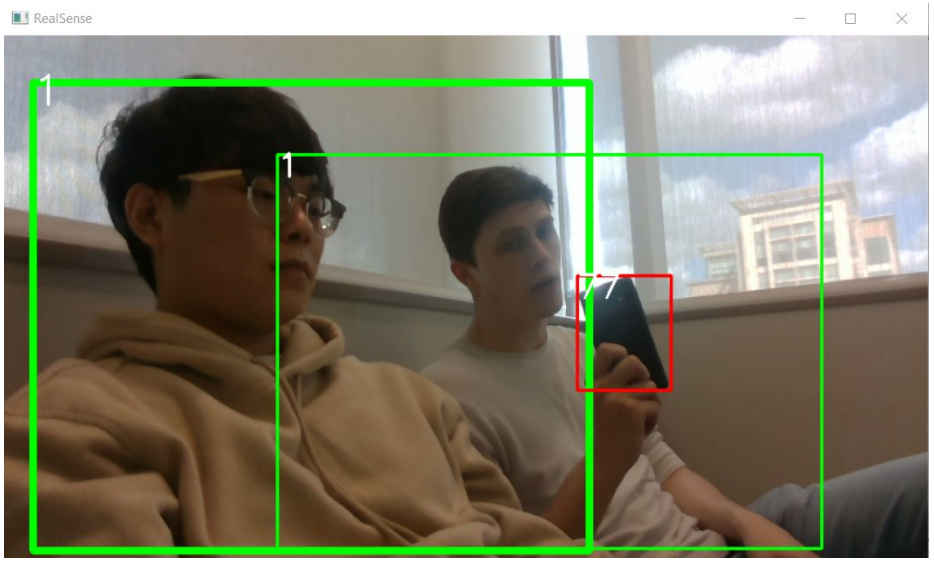
Tony Jeong


- Updated my code from 403 to label what the detected object is and how far it is from the camera.
- Successfully integrated my code to the raspberry pi 4 for better setup of camera.

# Engineering Design Accomplishments

Tony Jeong

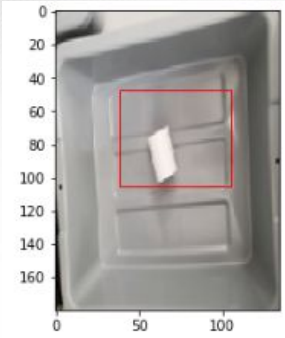


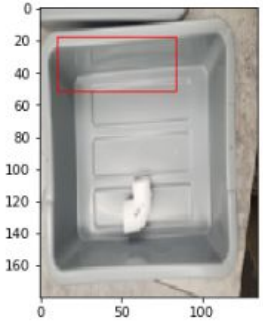

- My code will ask the user what type of pipe does he/she want and how many pieces.
- On the screen, the pieces that user wants will be highlighted in green and the bounding box will be bolder.

# Engineering Design Accomplishments

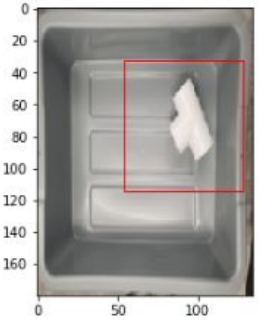
Evan Kolin



```
classification:  [ 12.256303   -29.048964     0.09246722]
localization:  [0.28325823 0.2619067  0.7787104  0.58345985]
```

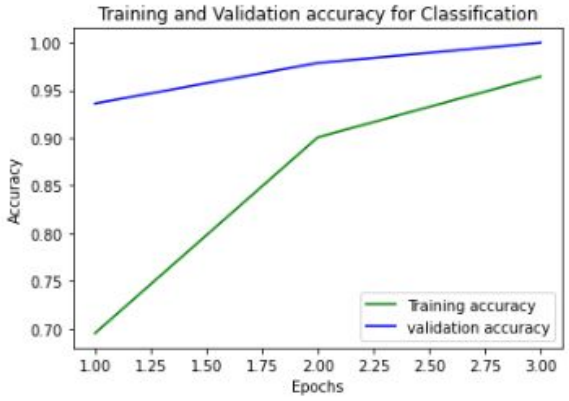


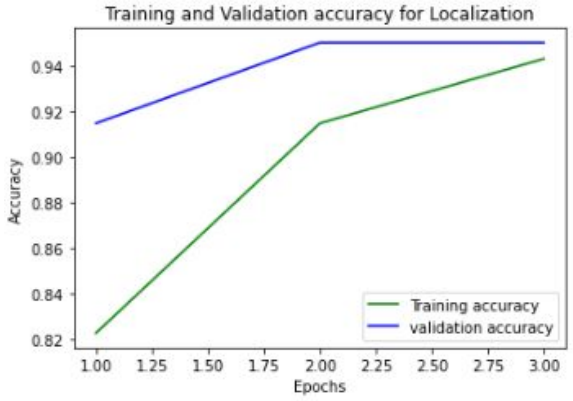
```
classification:  [-23.938196   17.707718   -2.3412948]
localization:  [0.07544905 0.09499556 0.61931837 0.28371584]
```



```
classification:  [ -6.888317 -14.068576  10.037672]
localization:  [0.39973783 0.17988908 0.9534514  0.6332836 ]
```

```
Confusion Matrix Classification
[[47  0  0]
 [ 0 43  0]
 [ 0  0 51]]
Classification Report
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        47
           1       1.00      1.00      1.00        43
           2       1.00      1.00      1.00        51

    accuracy                           1.00       141
   macro avg       1.00      1.00      1.00       141
weighted avg       1.00      1.00      1.00       141
```



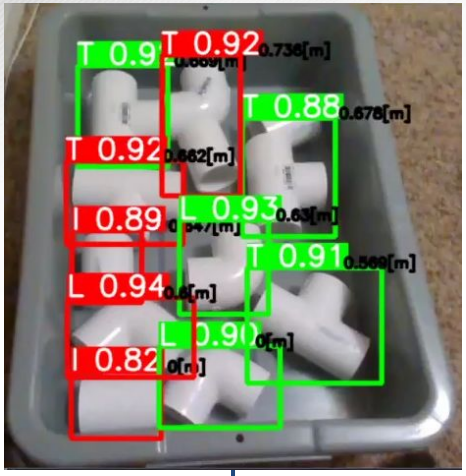



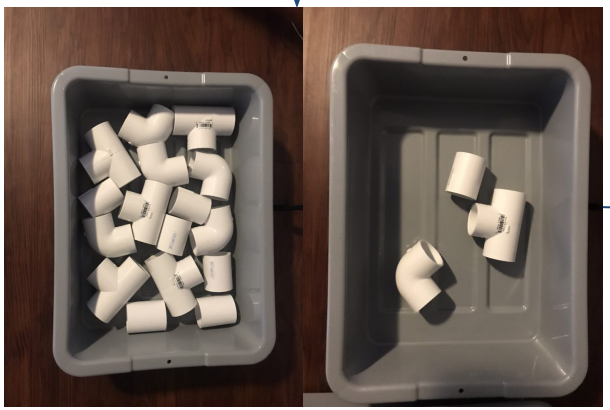
# Engineering Design Accomplishments

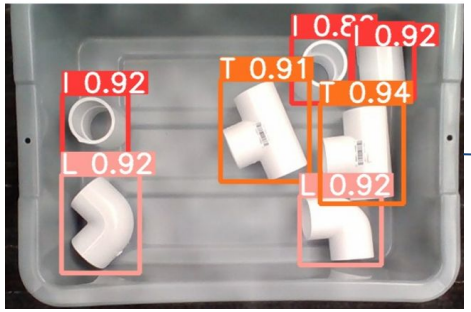
## Evan Kolin

| Challenges | | Solution |
|---|---|---|
| 1 | Requirements for what my model was supposed to do in FSR changed 5 weeks ago, requiring me to build it from scratch. Must now do classification and localization on multiple objects, instead of just classification on one object. | Rebuilt model from scratch. |
| 2 | Could not simply drop my model into a camera subsystems because it needed to go through YoLo training to detect multiple objects at once. | Completely abandon my model and use Hannah's trained YoLo model. |

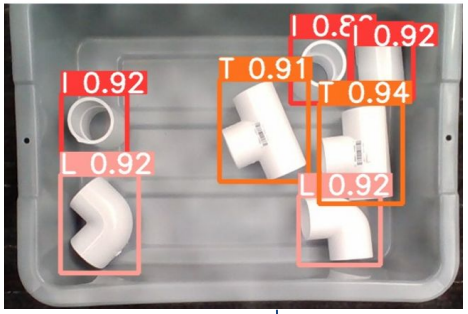
# Integrated System Results






Error Detection Code




```
PS C:\Users\hanna\yolov5-final\yolov5> python final_code.py
data/images/image.jpg written!
[ WARN:1] global C:\Users\runneradmin\AppData\Local\Temp\pip-req-build-sn_xpupm\opencv\modules\videoio\src\cap_msmf.cpp (438)
`anonymous-namespace'::SourceReaderCB::~SourceReaderCB terminating async callback
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 4 Is, 3 Ls, 2 Ts, Done. (0.263s)
Enter the number of I shaped PVCs: 7
Enter the number of L shaped PVCs: 1
Enter the number of T shaped PVCs: 2
Name:data/images/image.jpg
YOLOv5  v6.0-54-gac2c49a torch 1.9.1+cpu CPU

Fusing layers...
Model Summary: 213 layers, 7018216 parameters, 0 gradients, 15.8 GFLOPs
image 1/1 C:\Users\hanna\yolov5-final\yolov5\data\images\image.jpg: 480x640 4 Is, 3 Ls, 2 Ts, Done. (0.343s)
{'I': 4, 'L': 3, 'T': 2}
Error! 3 I is/are missing
Error! 2 L is/are excess
 3 I added to the CURRENT BIN from the PARTS BIN
 2 L removed from the CURRENT BIN to the PARTS BIN
PS C:\Users\hanna\yolov5-final\yolov5>
```

# Conclusions

## Changes from FSR/ICD:

- Evans model was cut from system
- Replace YOLOv3 model with YOLOv5 model
- Error detection no longer detects unknown objects

## Current status:

- Complete integration onto Pi for 2D system
- Integrate YOLO model into 3D subsystem
- Finish occlusion algorithm

# Thank You

Questions?