



A YOLO-Based Semi-Automated Labeling Approach to Improve Fault Detection Efficiency in Railroad Videos

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Outline

Basic Introduction to YOLO

Problem Formulation

Extracting Label Information

Covering the Assisted Labeling Method

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Problem Formulation

YOLOv8 requires a large dataset to be accurate.

Each image in the dataset needs to be labeled.

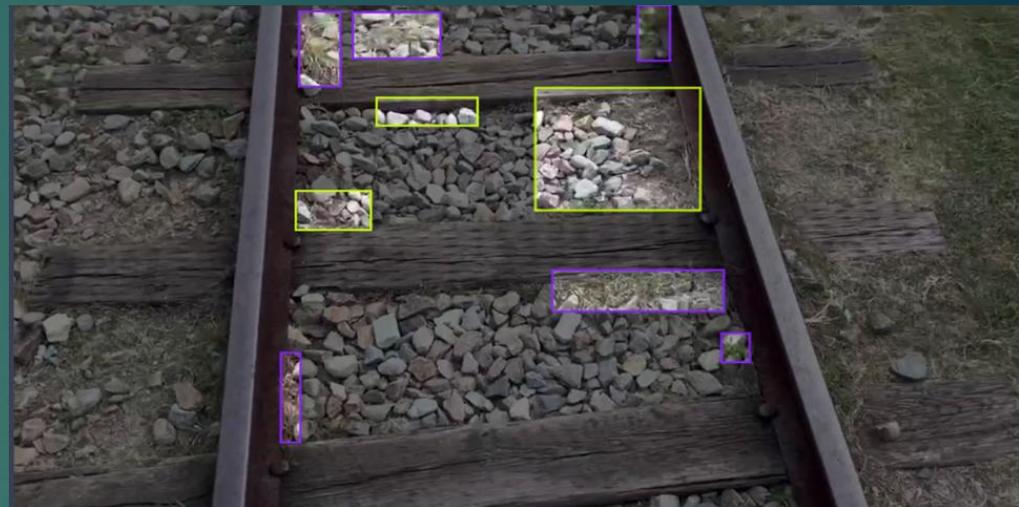
The labeling process is costly and labor intensive.

Manual labeling can be prone to errors.

Labeling in cases where object definitions can be ambiguous, such as "insufficient ballast" can be difficult.

There are assisted labeling techniques out there, but they are costly. Such as Roboflow Premium.

To try and solve this we employed our own assisted labeling technique that can be used by researchers.



Example Annotated Image from the Dataset.

Extracting Labels

Using a trained YOLO Model to detect objects.

Modify the label output from YOLO

Generate a Label Map

Assign coordinates to each bounding box.

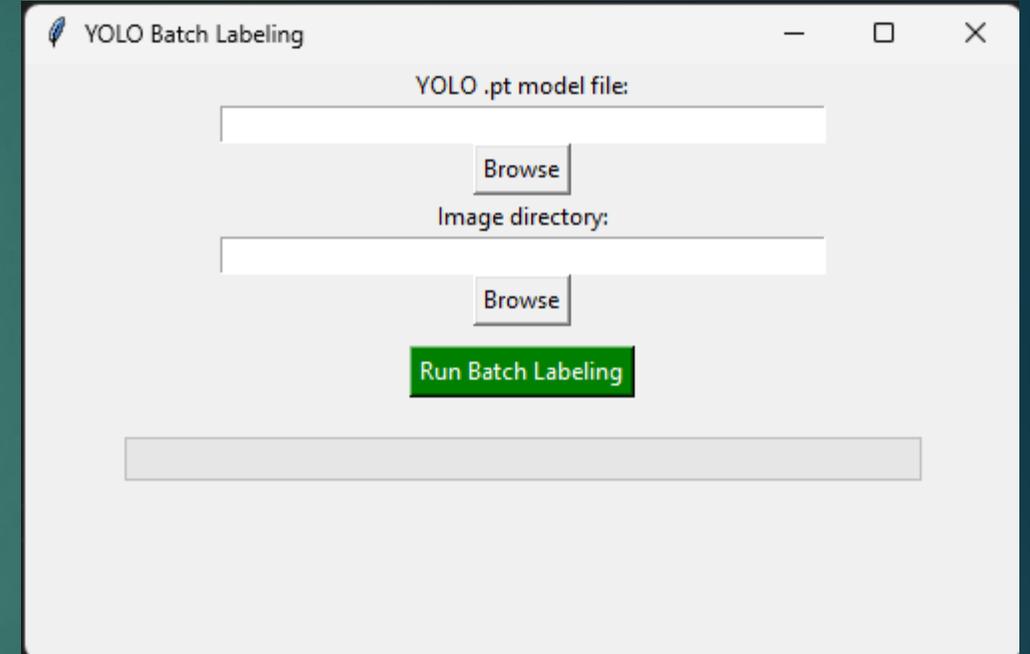
X center point

Y center point

Width

Height

Class id number



File Edit Selection ... gui

EXPLORER

test_GUI.py

```
test_GUI.py > run_detection
19 def select_image_folder():
20     folder_path = filedialog.askdirectory(title="Select image directory")
21     if folder_path:
22         image_folder_entry.delete(0, tk.END)
23         image_folder_entry.insert(0, folder_path)
24
25 def run_detection():
26     model_path = model_entry.get()
27     image_folder = image_folder_entry.get()
28
29     if not os.path.exists(model_path) or not model_path.endswith('.pt'):
30         messagebox.showerror("Error", "Please select a valid .pt model file")
31         return
32
33     if not os.path.isdir(image_folder):
34         messagebox.showerror("Error", "Please select a valid image directory")
35         return
36
37     output_dir = os.path.join(image_folder, "output")
38     debug_dir = os.path.join(output_dir, "debug")
39
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

Python Python

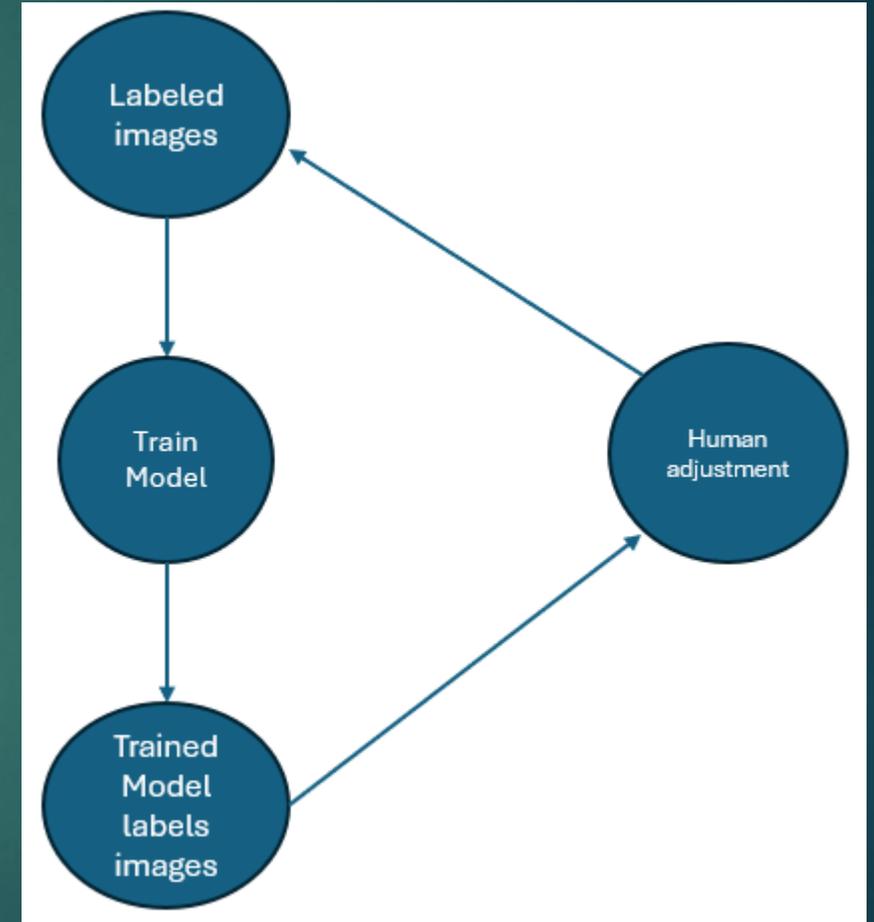
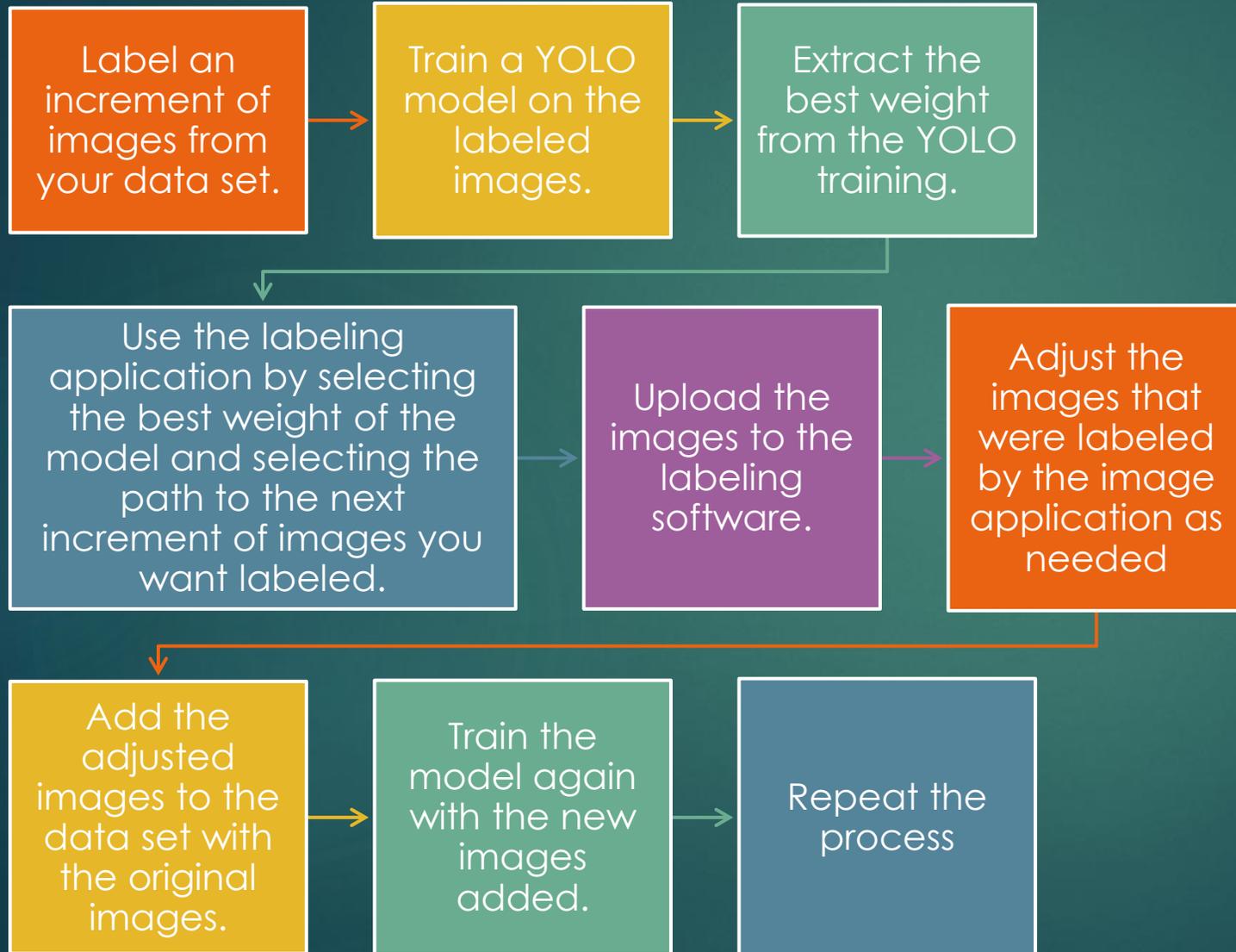
```
0: 384x640 1 1 plant_ballast, 133.6ms
Speed: 0.9ms preprocess, 133.6ms inference, 0.6ms postprocess per image at shape (1, 3, 384, 640)

0: 384x640 1 1 plant_ballast, 123.9ms
Speed: 0.8ms preprocess, 123.9ms inference, 0.6ms postprocess per image at shape (1, 3, 384, 640)

0: 384x640 1 1 plant_ballast, 138.3ms
Speed: 1.7ms preprocess, 138.3ms inference, 0.6ms postprocess per image at shape (1, 3, 384, 640)
PS C:\Users\alest\Desktop\gui>
```

Ln 53, Col 39 Spaces: 4 UTF-8 CRLF Python 3.10.11 64-bit (microsoft store)

Assisted Labeling Process



Result Evaluation



To evaluate the results, we used the F1-score of each model.



Focuses on evaluating class-wise performance.



Compares precision and recall



Ranges from 0%-100%, higher score indicates better performance.

$$\text{Precision} = \frac{TP}{TP + FP}$$

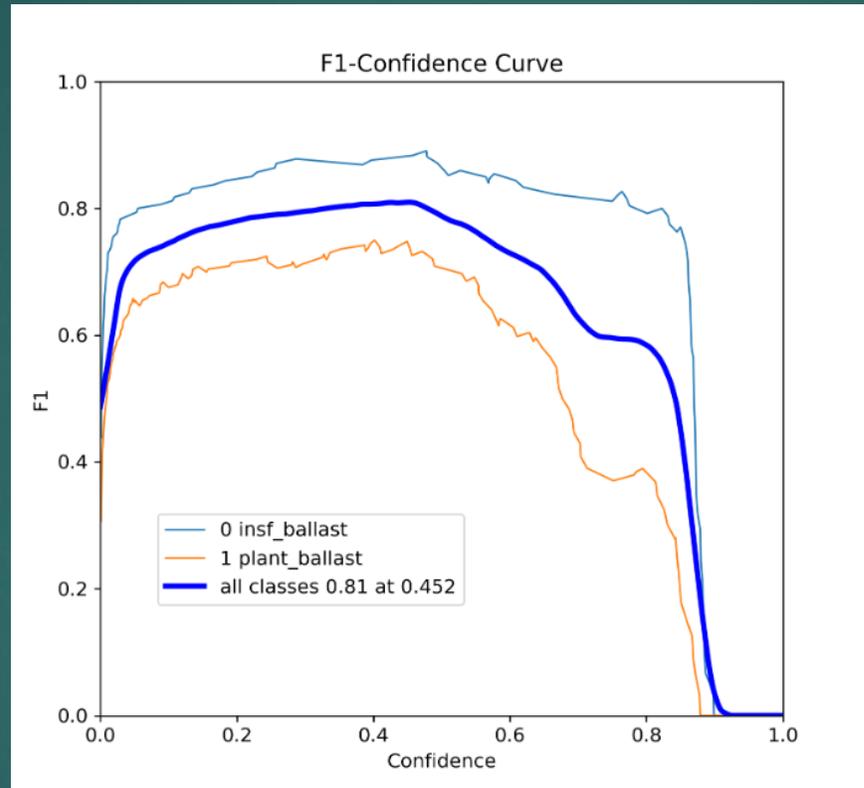
$$\text{Recall} = \frac{TP}{TP + FN}$$

$$F1 - \text{score} = 2 * \frac{\text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}}$$

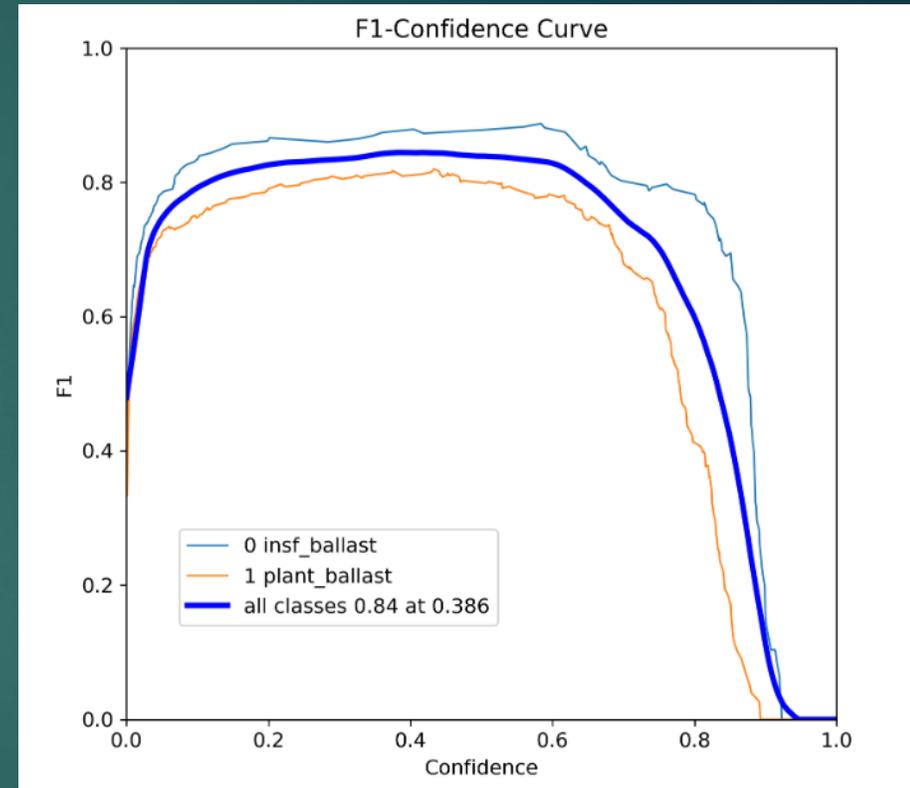
F1-Score Comparison

Model was found to improve after each iteration of assisted labeling technique.

The final model had an F-1 Score of 0.87

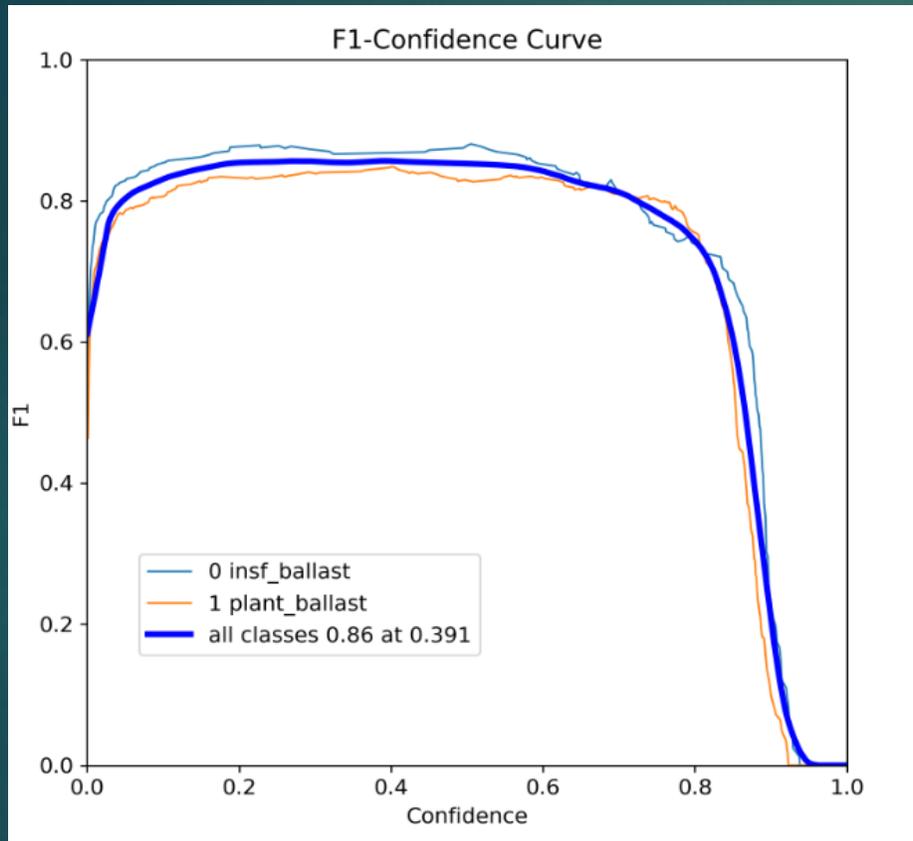


F1-Score of 100 image set (manually labeled)

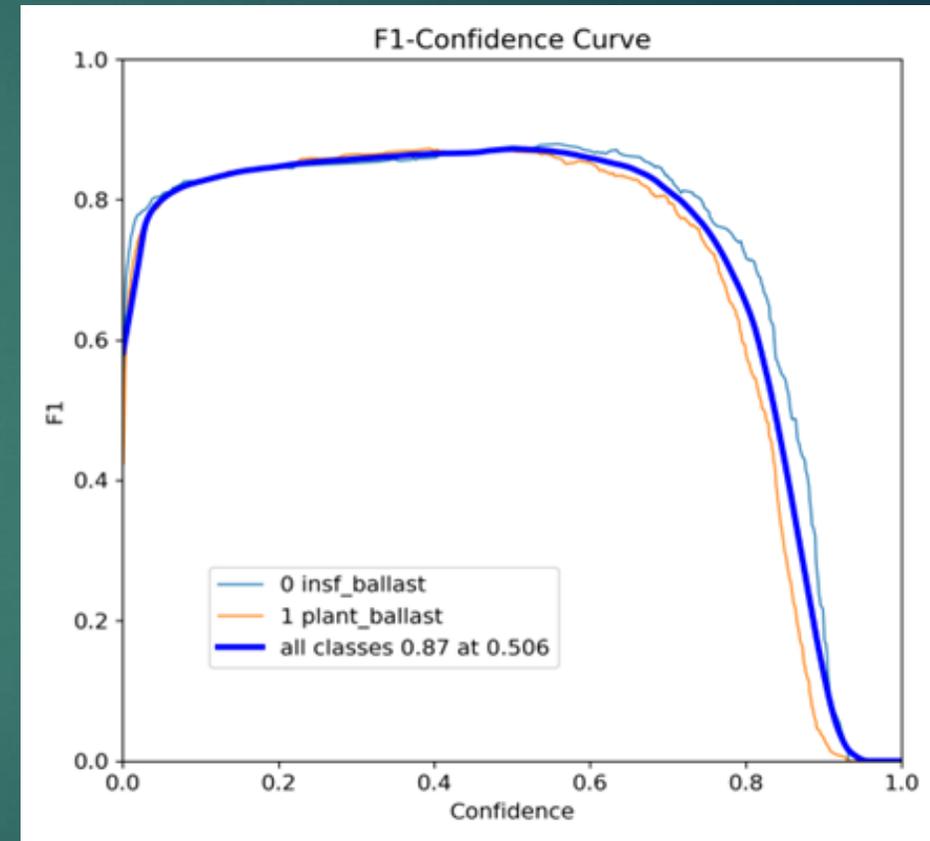


F1-Score of 200 image set (100 manually labeled+100 assisted)

F-1 Score Comparison Continued



F1-Score of 300 Image Set (100 manually labeled + 200 assisted)



F1-Score of 400 Image Set (100 manually labeled + 300 assisted)

Comprehensive View of Training Results

F1-Scores of Labeling Strategies

Data Set	F1-Score
100-image set (manually labeled)	0.81
200-image set (100 manual+100 assisted)	0.84
300-image set (100 manual+200 assisted)	0.86
400-image set (100 manual+300 assisted)	0.87
Baseline model (400 images manually labeled)	0.89

Future Work

Collect

Collect data with depth information by using depth sensor.

Modify

Modify YOLO architecture to be able to support a depth distance information.

Apply

Apply reinforcement learning to the labeling technique.



Questions?