Group 4: Autonomous Sorting of Trash Objects Based on Structure using Gazebo Robot Simulation

Dhyakesh Soundararajan, Saffat Ahmed, Kevan Mehta

Introduction

Goal: Create autonomous robot that can detect and sort various trash objects

Reason: Assisting with proper disposal and sorting of waste

Objectives:

- Detecting and Differentiating between various objects
  - DOPE - Deep Object Pose Estimation
  - Image Classification with Tensorflow
- Consistent and Accurate Grasping of objects
  - MoveIt Motion Planning Framework

Related Work - DOPE

Pre-trained Models for Pose Estimation

- Utilized pre-trained models for initial pose estimation.
- Requires all objects to be known ahead of time
  - Useful for small dataset testing in simulation
  - Potentially not as useful in real world circumstance, too many shapes and objects to train all of them

ROS Implementation Challenges

- Struggled to get working on our systems. Missing certain files and libraries
- If implemented successfully, would require additional training for additional models if needed
- May attempt implementation again in future

Related Work - Image Classification

Model summary

```
Model: "sequential_8"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_25 (Conv2D)          (None, 222, 222, 32)      896

 max_pooling2d_25 (MaxPooli  (None, 111, 111, 32)      0
 ng2D)

 conv2d_26 (Conv2D)          (None, 109, 109, 64)      18496

 max_pooling2d_26 (MaxPooli  (None, 54, 54, 64)        0
 ng2D)

 conv2d_27 (Conv2D)          (None, 52, 52, 128)       73856

 max_pooling2d_27 (MaxPooli  (None, 26, 26, 128)       0
 ng2D)

 flatten_8 (Flatten)         (None, 86528)             0

 dense_16 (Dense)            (None, 128)               11075712

 dense_17 (Dense)            (None, 2)                 258

=================================================================
Total params: 11169218 (42.61 MB)
Trainable params: 11169218 (42.61 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

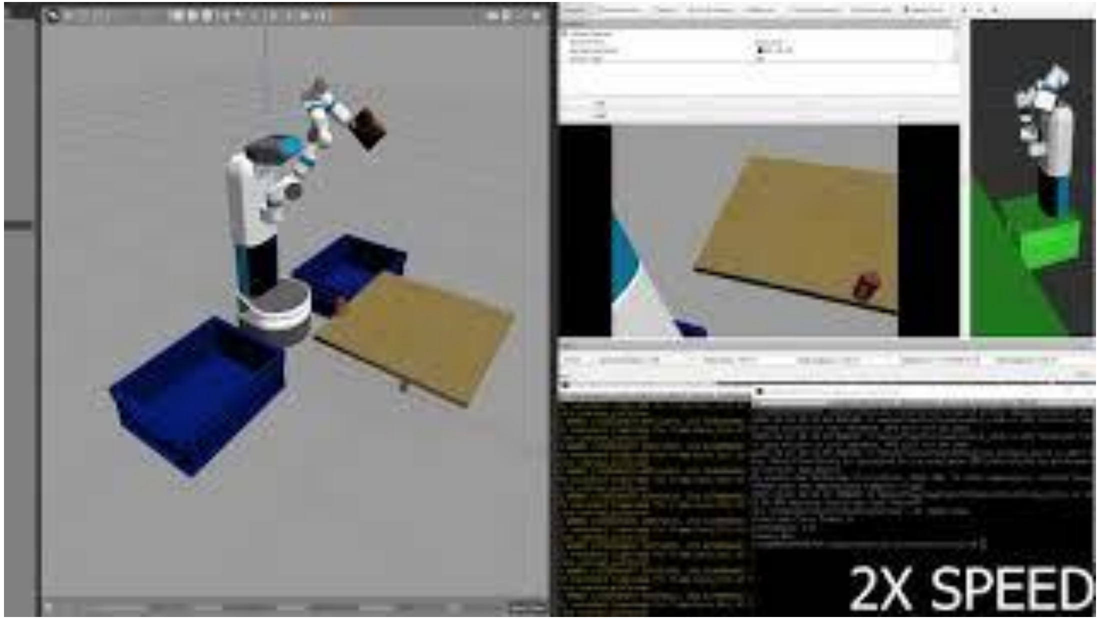
Implementation

- Gazebo for Simulations and Collecting Classification Images
- MoveIt for Grasping
- Classification using Tensorflow
- Current Model trained on boxes and cans

Collecting Sample Input Images Demo

https://youtu.be/Qx4bh3lSySg

Demonstration of Current Implementation



https://youtu.be/W6Qgq94Xr7E

Experiments and Data

Dataset stats:

Train:

Box:50

Can:51

Val:

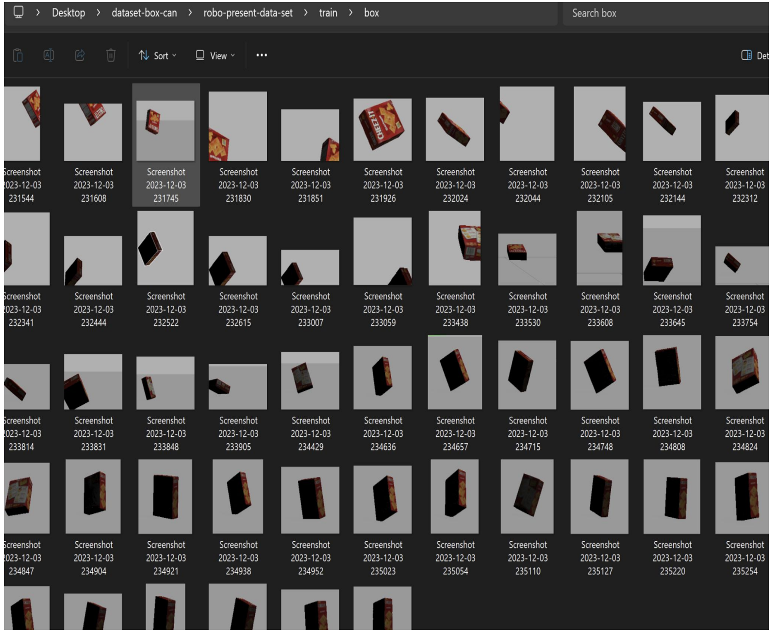
Box:15

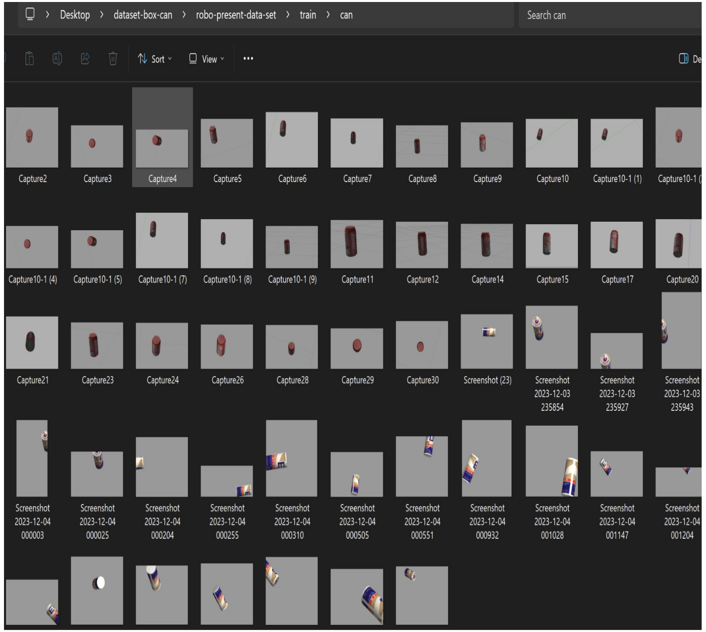
Can:15

Test:

Box:10

Can:10

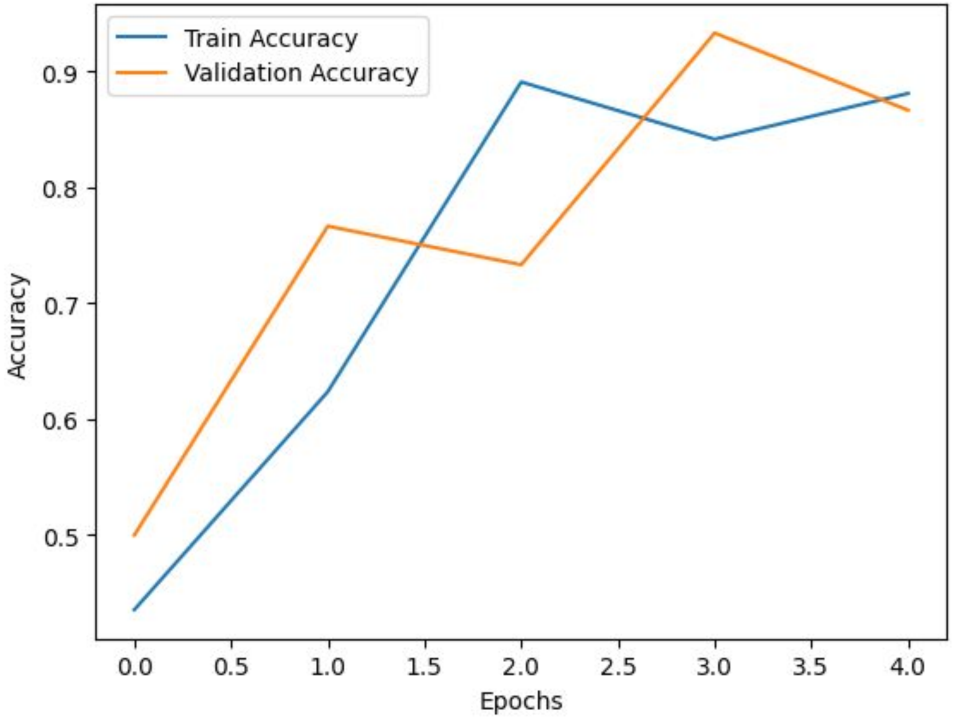




Experiments and Data

Training and Validation accuracy

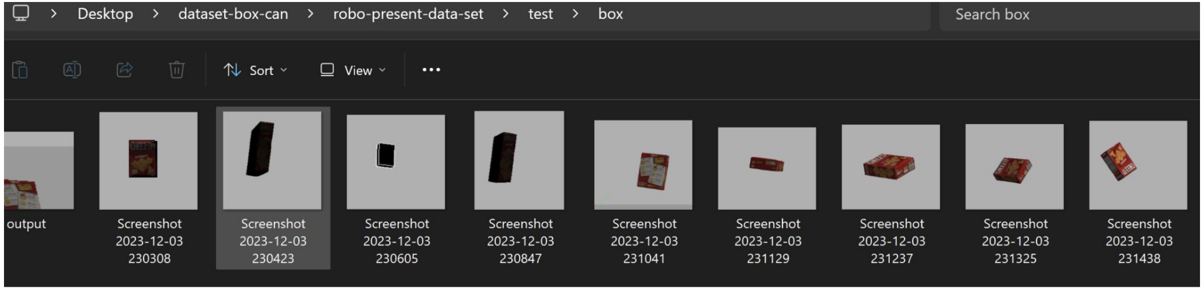
Graph(5 epochs)

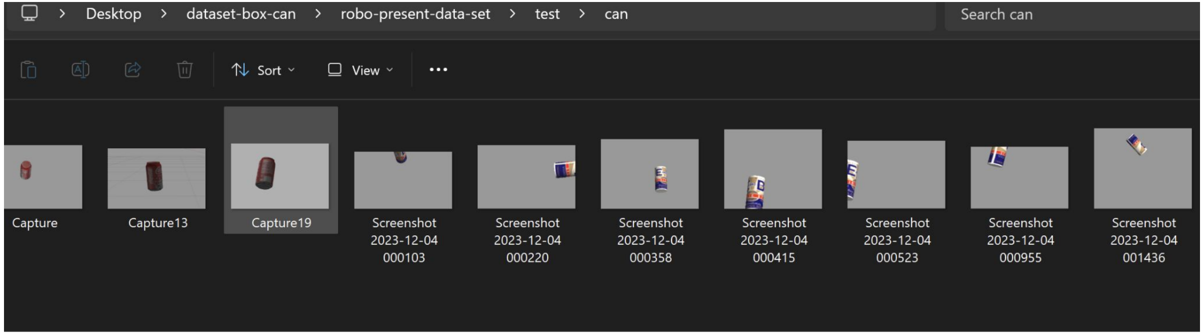


Analysis of Results/Limitations

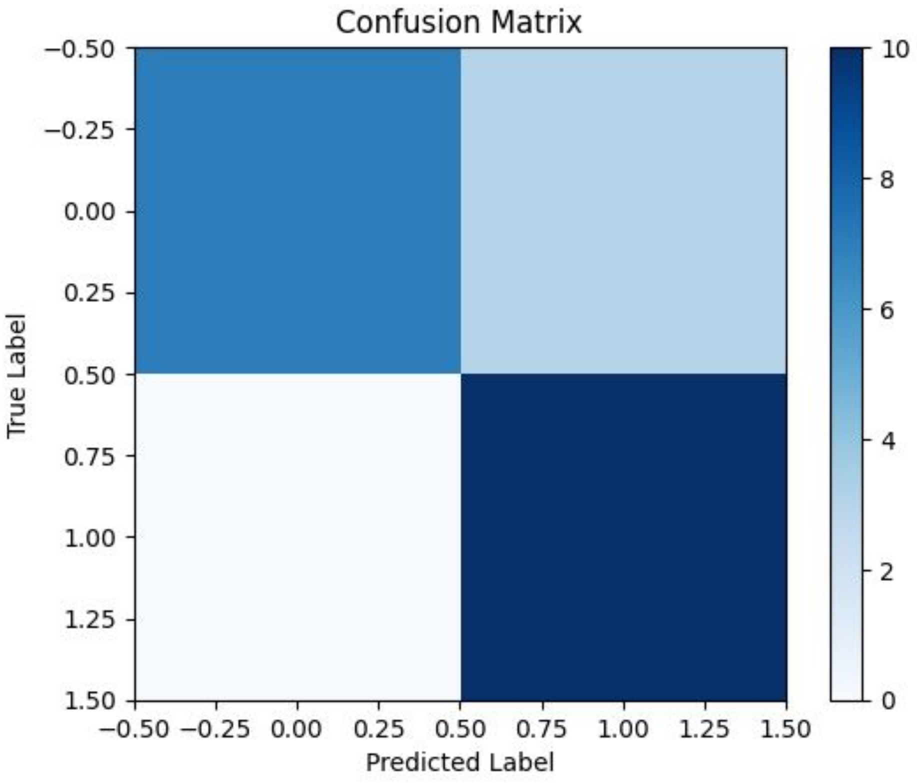
Testing Data sample

To evaluate the model





Analysis of Results/Limitations



Confusion matrix

Box [[7, 3]

Can [0, 10]]

Accuracy: 0.85

Testing model on the fetch robot camera

```python
model.save('custom_image_classifier_box_can.h5')
# Provide the path to the image you want to classify
image_path = '/content/image_158.png'

# Make a prediction
class_index, class_confidence = classify_image(image_path)

# Print the result
print(f"Predicted Class Index: {class_index}")
print(f"Confidence: {class_confidence}")
```

```
1/1 [==============================] - 0s 131ms/step
Predicted Class Index: 0
Confidence: 1.0
```

image_158.png

Future Work

Improve Object Recognition

- Enhance the robot's ability to recognize diverse trash items.
- Handle deformable or complex objects effectively.
- Distinguish between different materials for precise sorting.

Improve Grasping

- Implement models with defined potential grasps
- Using CNN’s for grasp learning
- Focus on top-down grasping instead of 6D grasping

References

- J. Tremblay, T. To, B. Sundaralingam, Y. Xiang, D. Fox, and S. Birchfield, "Deep object pose estimation for semantic robotic grasping of household objects," arXiv preprint arXiv:1809.10790, 2018.
- X. Zhu, D. Wang, O. Biza, G. Su, R. Walters, and R. Platt, "Sample efficient grasp learning using equivariant models," arXiv preprint arXiv:2202.09468, 2022.
- Sachin Chitta, Ioan Sucan, and Steve Cousins. Moveit! [rostopics]. IEEE Robotics & Automation Magazine, 19(1):18–19, 2012.

Thank You

Questions?