ROS - EXTERNSHIP PROJECT REPORT
(July 2021)

An Object Detection Robot Simulation using ROS (Robot Operating System)

Team members:

Kavish Mehta - 18BIS0130
Prem Sharan - 19BEE0003
Shree Varshan V - 19BCE1648
Abishek.R - 18BEC0531

Contents:

1) Introduction **2**

a) Overview …………………………………………………………………2

b) Purpose ………………………………………………………………… 2

2) Literature Survey **3**

a) Existing problem ………………………………………………………….. 3

b) Proposed solution ………………………………………………………… 3

3) Theoretical analysis **4**

a) Block diagram ……………………………………………………………….. 4

b) Hardware/Software design ………………………………………………... 4

4) Flowchart **5**

5) Result **6**

6) Advantages & Disadvantages **9**

7) Applications **10**

8) Conclusion **10**

9) Future scope **11**

10) Bibliography **11**

11) Appendix **12**

a) Source code ……………………………………………………………12

b) Robot output screenshot ……………………………………………… 12

Introduction

Overview:

Object detection is a computer vision technique that allows us to identify and locate objects in an image or video. With this kind of identification and localization, object detection can be used to count objects in a scene and determine and track their precise locations, all while accurately labeling them.Objects can be recognized by a robot with the use of a vision system. It is based on image characteristics like points, lines, edges, colours and their relative positions.

Processing of object detection and recognition consists of two steps. First is teaching and it should be executed before main robot operation. During this step, an object is presented to the vision system, image and extracted set of features are saved as a pattern. Many objects can be presented to the system.

Second step is actual recognition which is executed constantly during robot operation. Every frame of the camera is processed, image features are extracted and compared to data set in the memory. If enough features match the pattern, then the object is recognized.

Purpose:

Object detection is inextricably linked to other similar computer vision techniques like image recognition and image segmentation, in that it helps us understand and analyze scenes in images or video.

But there are important differences. Image recognition only outputs a class label for an identified object, and image segmentation creates a pixel-level understanding of a scene's elements. What separates object detection from these other tasks is its unique ability to locate objects within an image or video. This then allows us to count and then track those objects.

Literature Survey

[1] Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks Shaoqing Ren Kaiming He Ross Girshick Jian Sun.

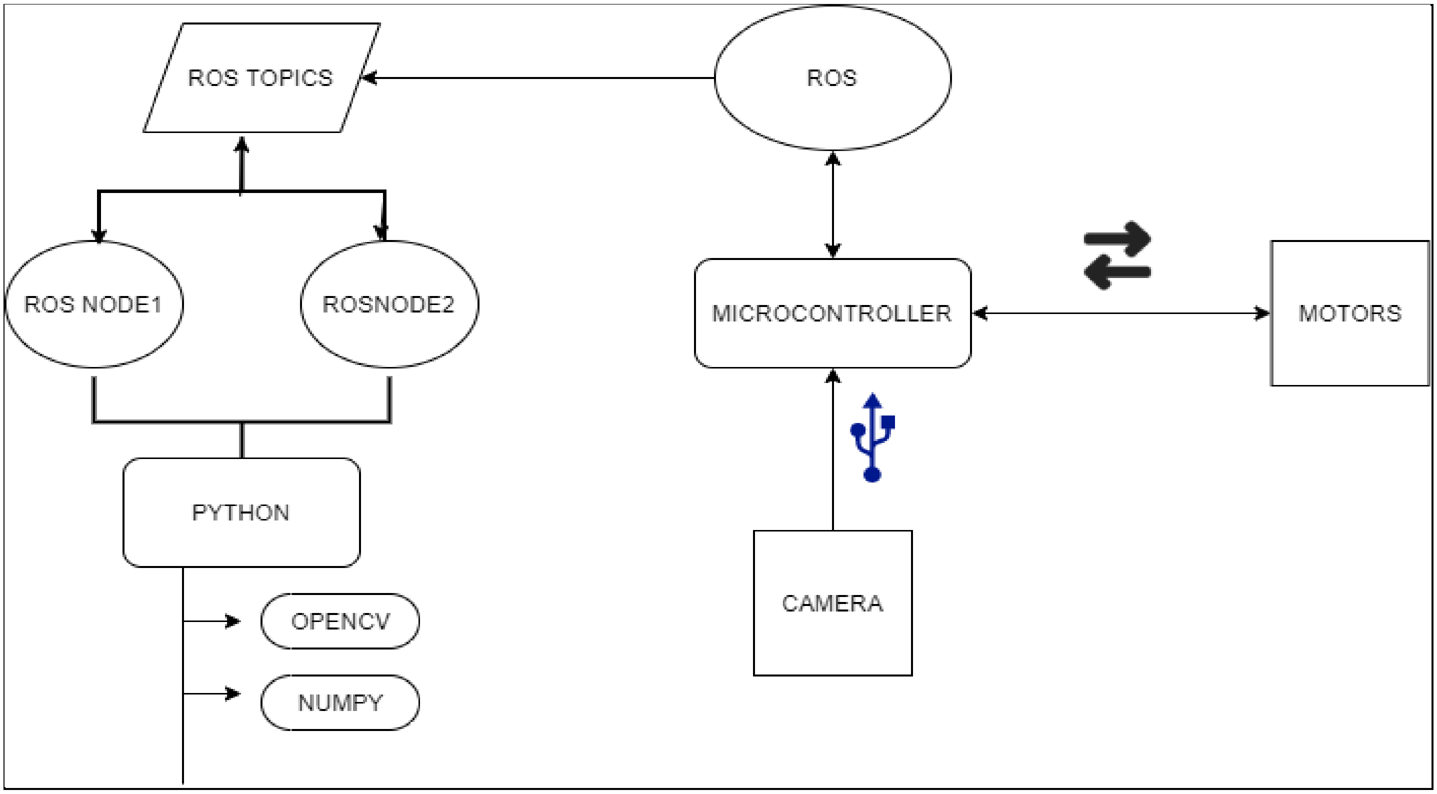
Abstract: State-of-the-art object detection networks depend on region proposal algorithms to hypothesize object locations. Advances like SPPnet and Fast R-CNN have reduced the running time of these detection networks, exposing region proposal computation as a bottleneck. In this work, we introduce a Region Proposal Network (RPN) that shares full-image convolutional features with the detection network, thus enabling nearly cost-free region proposals. An RPN is a fully-convolutional network that simultaneously predicts object bounds and objectness scores at each position. RPNs are trained end-to-end to generate high quality region proposals, which are used by Fast R-CNN for detection. With a simple alternating optimization, RPN and Fast R-CNN can be trained to share convolutional features.

[2] Deep Learning for Generic Object Detection: A Survey : Li Liu, Wanli Ouyang, Xiaogang Wang, Paul Fieguth, Jie Chen, Xinwang Liu & Matti Pietikäinen

Abstract: Object detection, one of the most fundamental and challenging problems in computer vision, seeks to locate object instances from a large number of predefined categories in natural images. Deep learning techniques have emerged as a powerful strategy for learning feature representations directly from data and have led to remarkable breakthroughs in the field of generic object detection. Given this period of rapid evolution, the goal of this paper is to provide a comprehensive survey of the recent achievements in this field brought about by deep learning techniques.

Theoretical Analysis

Block diagram:



Hardware/Software Components:

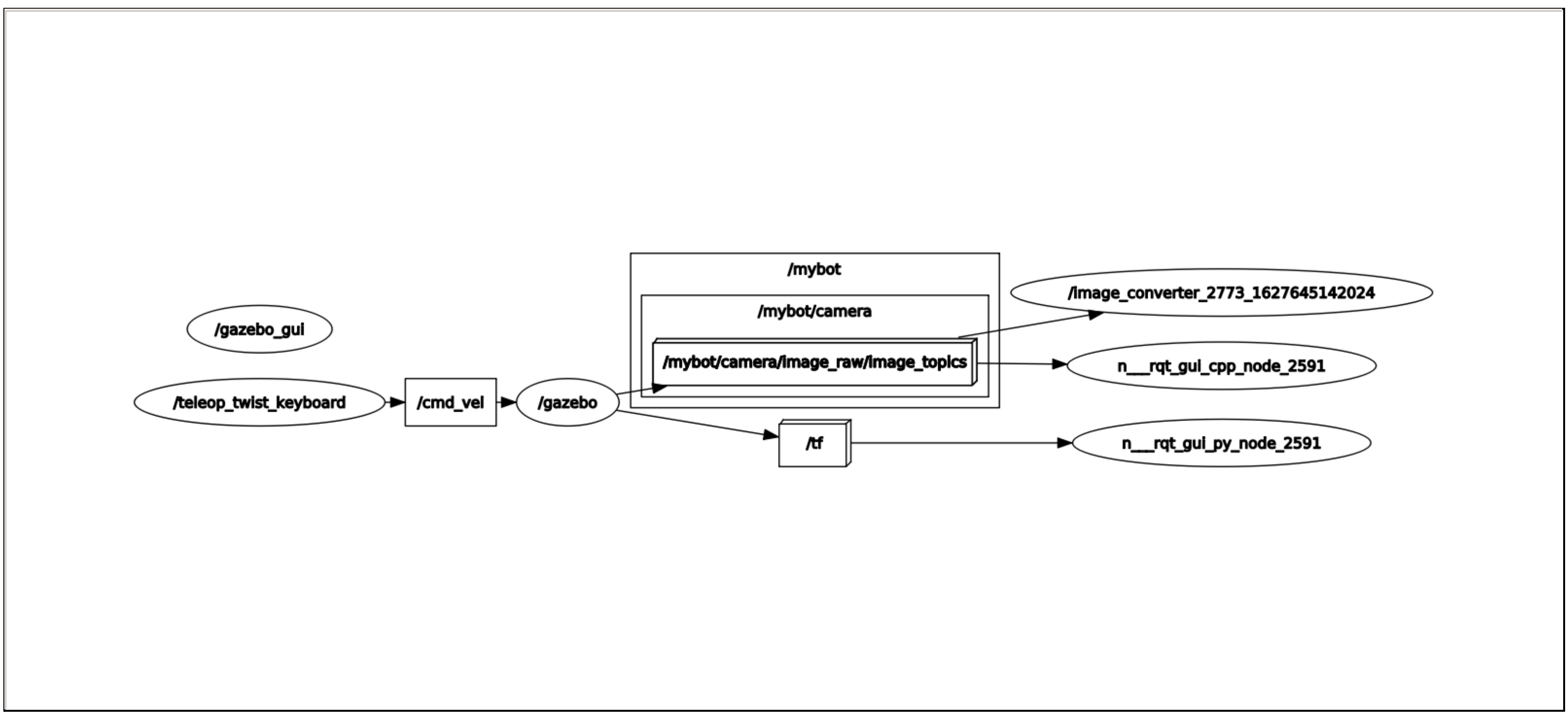
1) HARDWARE:

- Microcontroller with GPU, USB, GPIO support to connect various I/O devices and run ROS
- Encoder motors
- RGB USB Camera
- Motor Drivers
- Power management system

2) SOFTWARE:

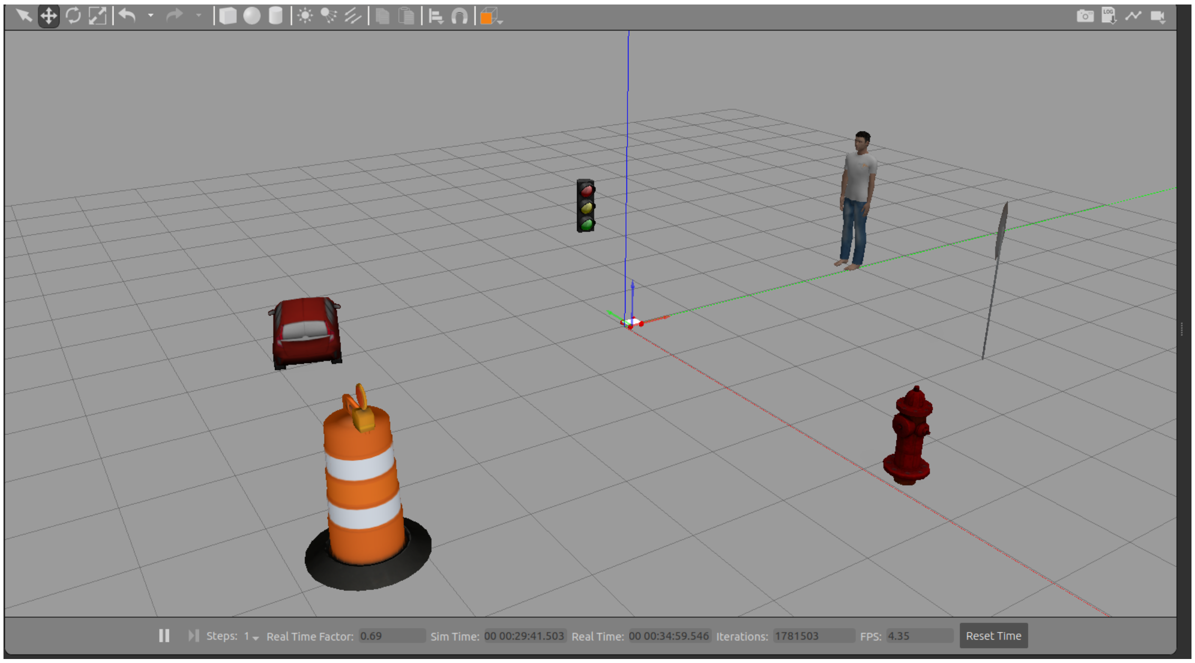
- Ubuntu OS
- Python Interpreter
- OpenCV and its dependency libraries
- ROS and its various dependencies

Flow chart

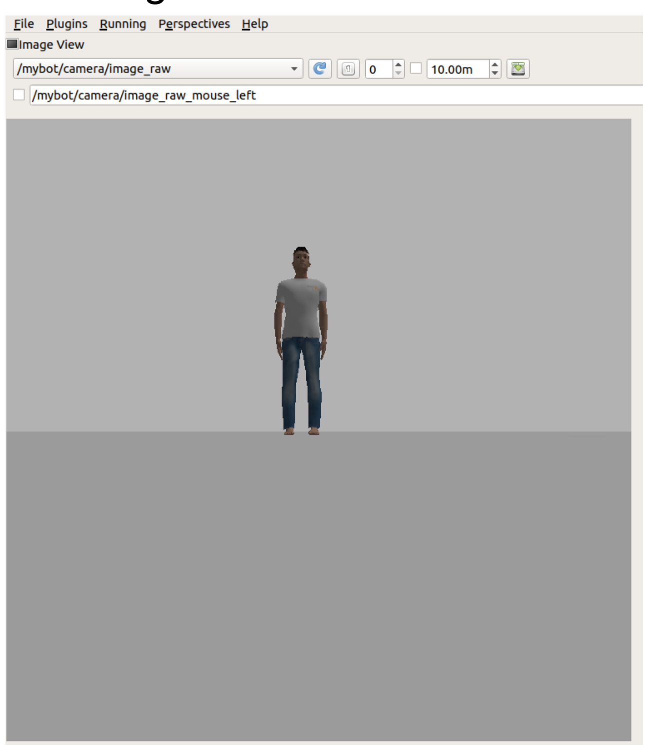


Result

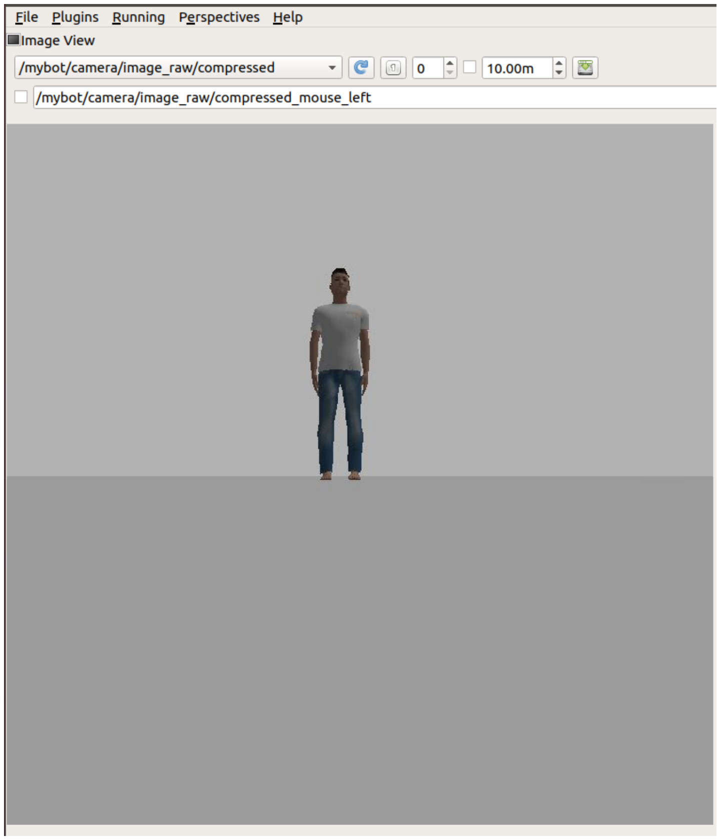
1. Robot spawned in the Gazebo World



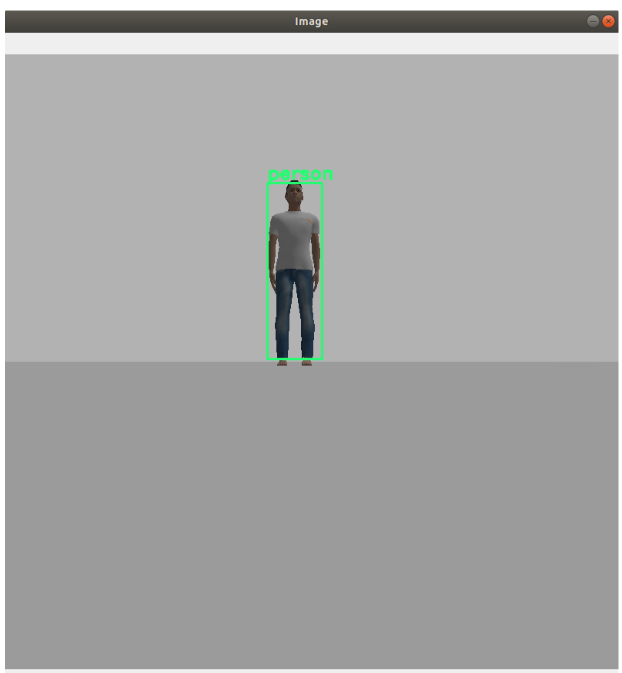
2. Raw Image Feed received from Bot -



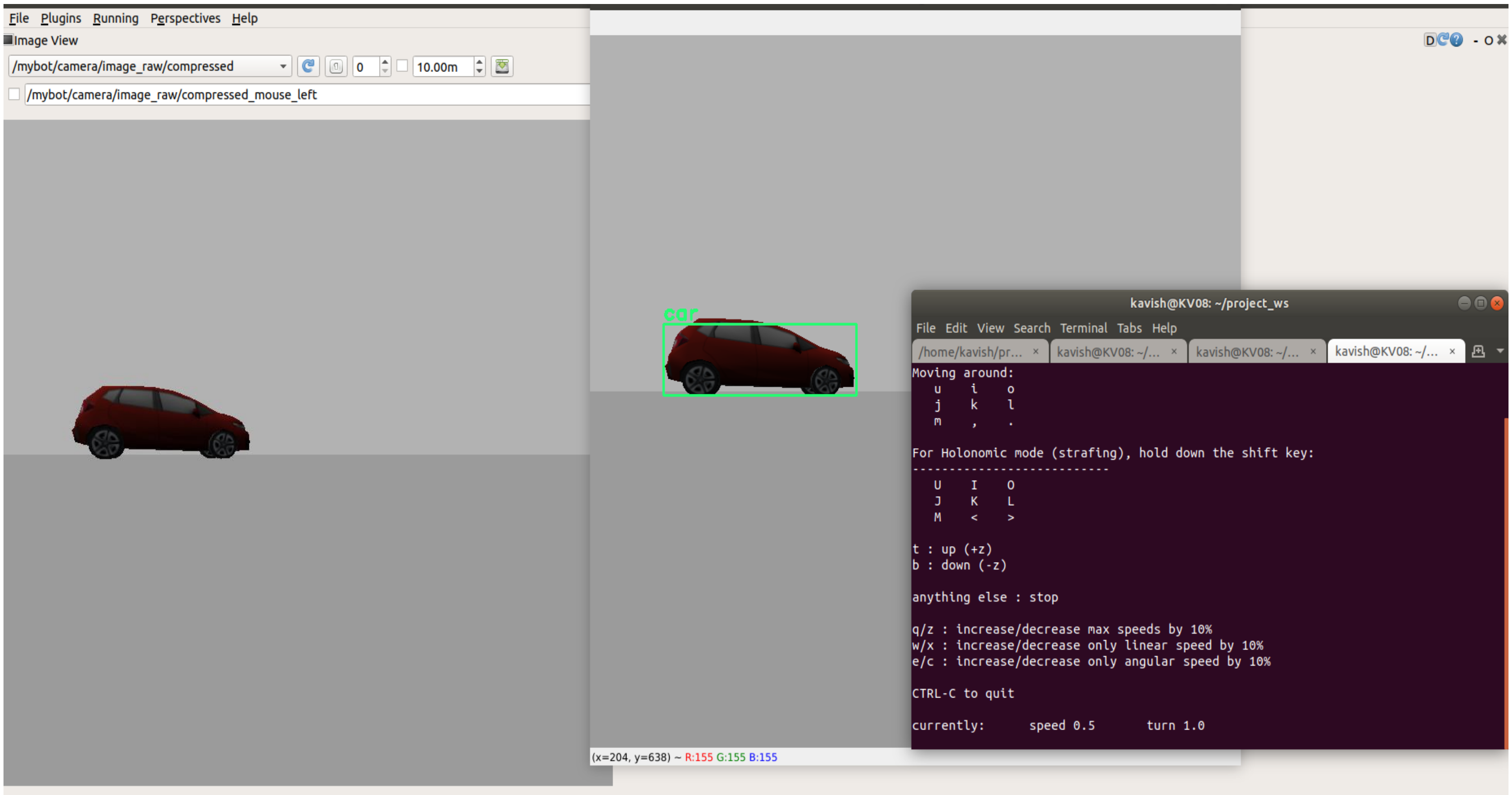
3. Compressed Image Feed used for object analysis -



4. Identification Of Object -



5. Rotating the robot with Teleop node and identifying another object in feed -



Advantages & Disadvantages

Advantages:

1) Saves time in identifying objects.
2) Help manage count of objects.
3) Classification of objects present in an environment becomes faster and easier.
4) Reduces human error.
5) Requires lesser resources in doing the same job as a human.

Disadvantages:

1) The object detected may produce error when viewed at different angles.
2) Object deformation is an exemption.
3) Object can be ignored if only a part of it is visible.
4) Highly affected by background illumination.
5) Objects having an affinity to camouflage with their surroundings can’t be detected (especially with cluttered or textured backgrounds).

Applications

This project has numerous applications and potential. So, it can be incorporated in fields like:

1) Crowd counting.
2) Self-driving cars.
3) Video surveillance.
4) Face detection.
5) Anomaly detection etc.

Conclusion

During the course of this project we as a team were able to successfully apply all the skills we had attained during the training period.
We have become immensely familiarized with the linux operating system and its terminal commands.

We have been able to develop and simulate robots in simulation environments such as gazebo available in ROS.

Alongside this we were successfully able to use CVbridge and integrate OpenCV object detection capabilities with our robot.

This project has shown the capabilities of ROS and how it can be implemented in real-time for various applications.

Due to the lack of a proper computing device, we were not able to achieve high accuracy for object detection and even the simulation was a bit laggy, but we assume that the same won't be the case when using specialised hardware and a camera of more resolution.

Future Scopes

In the future, the ability to detect objects bypassing the present limitations and difficulties can be developed which will provide enhanced services and capabilities to the present fields in which it is implemented in. Real-time object detection can be used in autonomous robots for various purposes.

Bibliography

[1] https://husarion.com/tutorials/ros-tutorials/4-visual-object-recognition/
[2]https://www.researchgate.net/publication/326572691_Importance_of_Humanoid_Robot_Detection
[3] https://www.fritz.ai/object-detection/
[4] https://www.ripublication.com/ijcir17/ijcirv13n5_07.pdf
[5] http://ethesis.nitrkl.ac.in/4836/1/211CS1049.pdf
[6] https://proceedings.neurips.cc/paper/2015/file/14bfa6bb14875e45bba028a21ed38046-Paper.pdf
[7] https://link.springer.com/article/10.1007/s11263-019-01247-4

Appendix

Source code:

https://github.com/Durgaprasad-SB/Object-Detection-Robot-using-ROS

Robot output: