

Service Robot for Garbage Segregation

USER MANUAL

by

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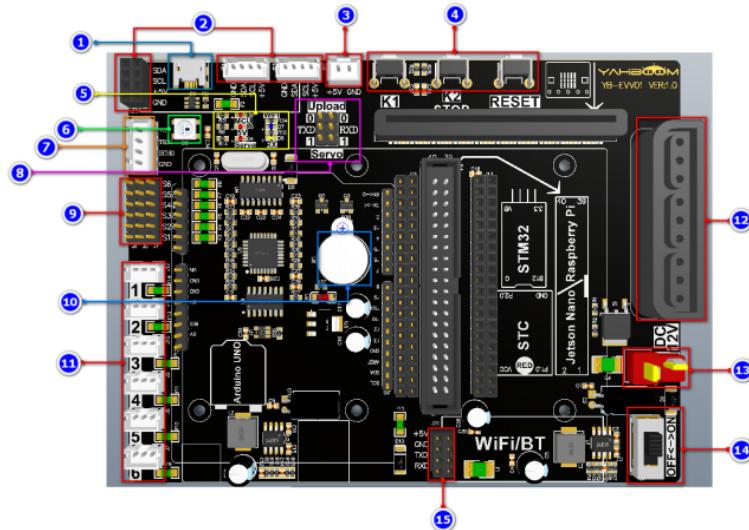
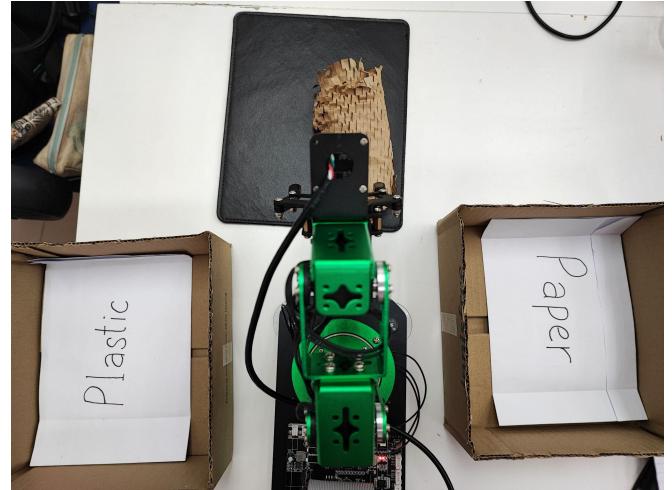
Related code can refer to the github link provided.

<https://github.com/jinghui00/Robotic-Garbage-Sorter.git>

https://github.com/joey0622/fyp2_Joey_PickAndPlaceRobot.git

Introduction

This project is using a robot named Yahboom Dofbot Raspberry Pi 4B. It has 6-DOF, using Ubuntu 20.04 and ROS Noetic.



- **K1 button:** In the default mode, press the K1 button once to reset the bus servo, and the DOFBOT keeps upright. Double-click the K1 button to reset the servo quickly.
- **K2 button:** Short press is the emergency stop function of the bus servo to turn off the torque of the bus servo; long press for about 10 seconds is to turn off and turn on the BootLoader function of the underlying single-chip microcomputer. After the BootLoader function is turned on, the RGB light shows a marquee effect.
- **RESET key:** The reset function of the coprocessor (STM8), STM32 and Arduino UNO.

Start the robot

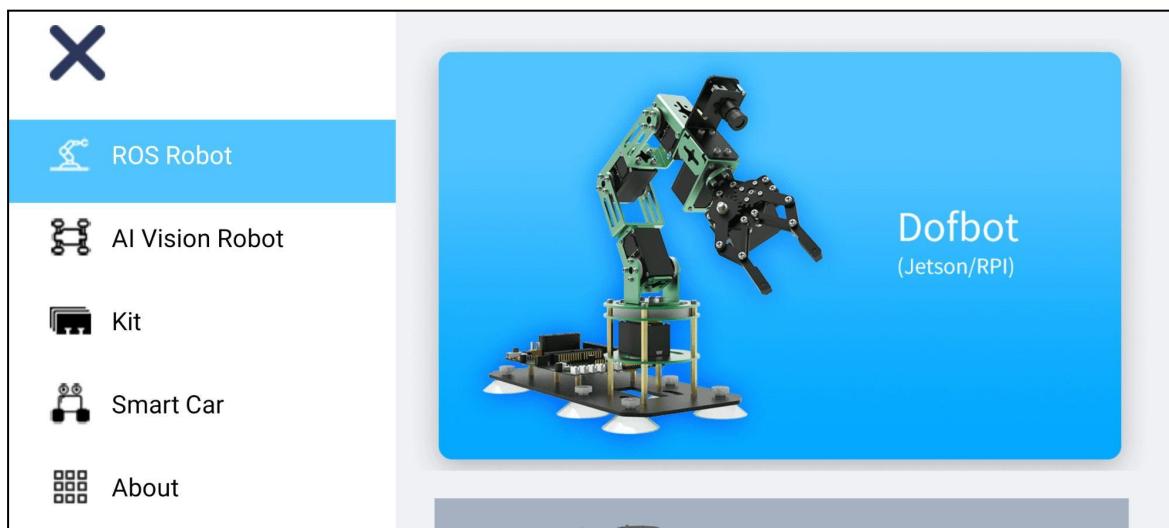
1. Plug in and switch on the robot.
2. Wait until the buzzer whistle 3 times, then the robot is successfully started

Connect robot to WiFi

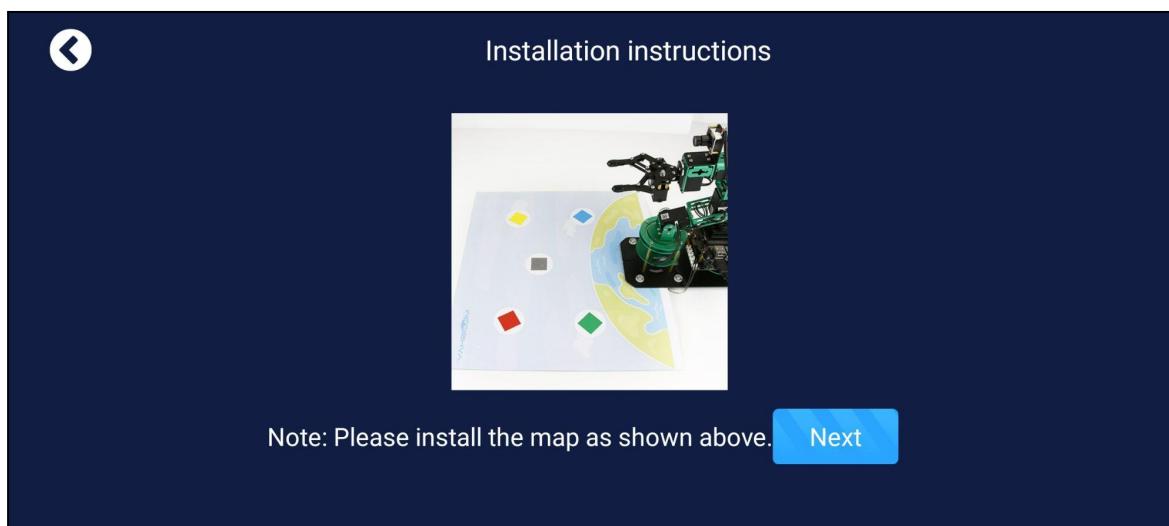
1. In your smartphone/mobile phone, go to Google Play Store (Android) or App Store (iOS) to install the “YahboomRobot” application.



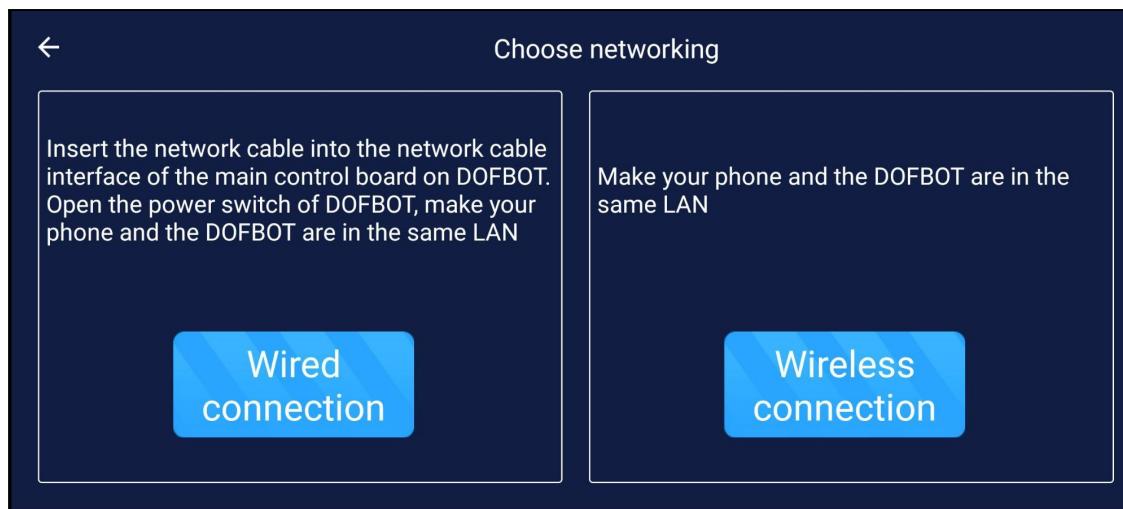
2. Open the application, choose “ROS Robot” and click “Dofbot(Jetson/RPI)”.



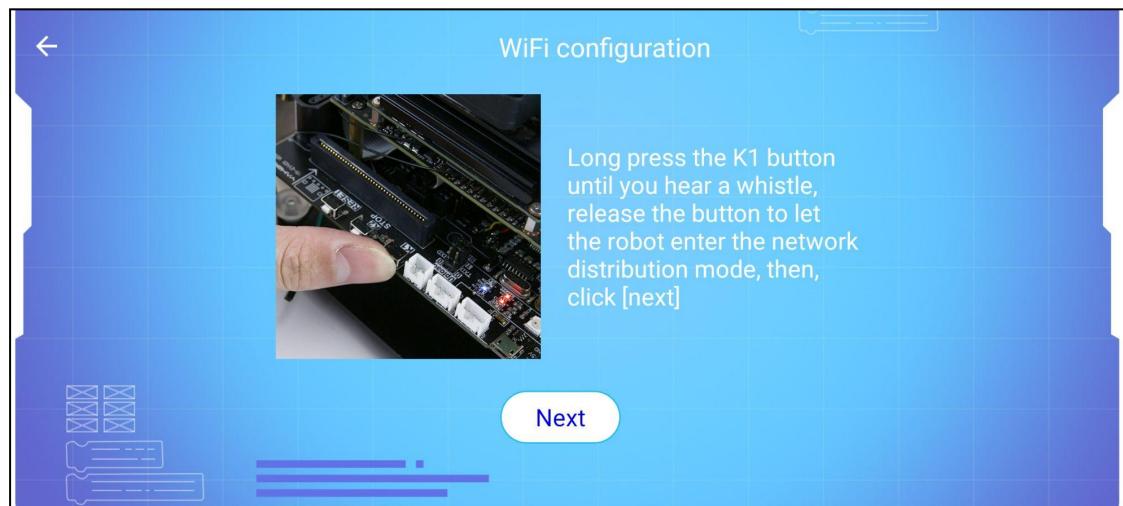
3. Ignore the installation instructions. Click “Next”.



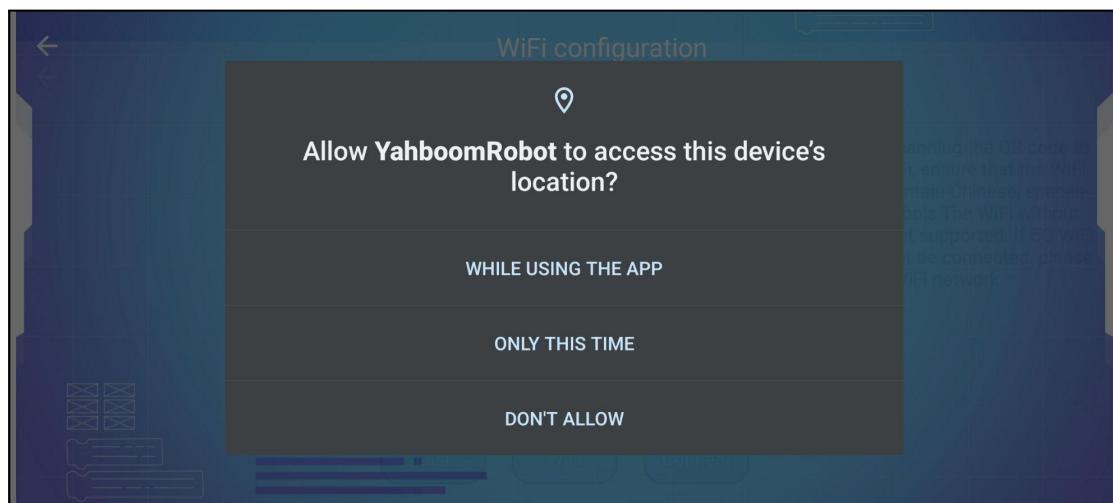
4. Choose “Wireless connection”.



5. Follow the instructions.



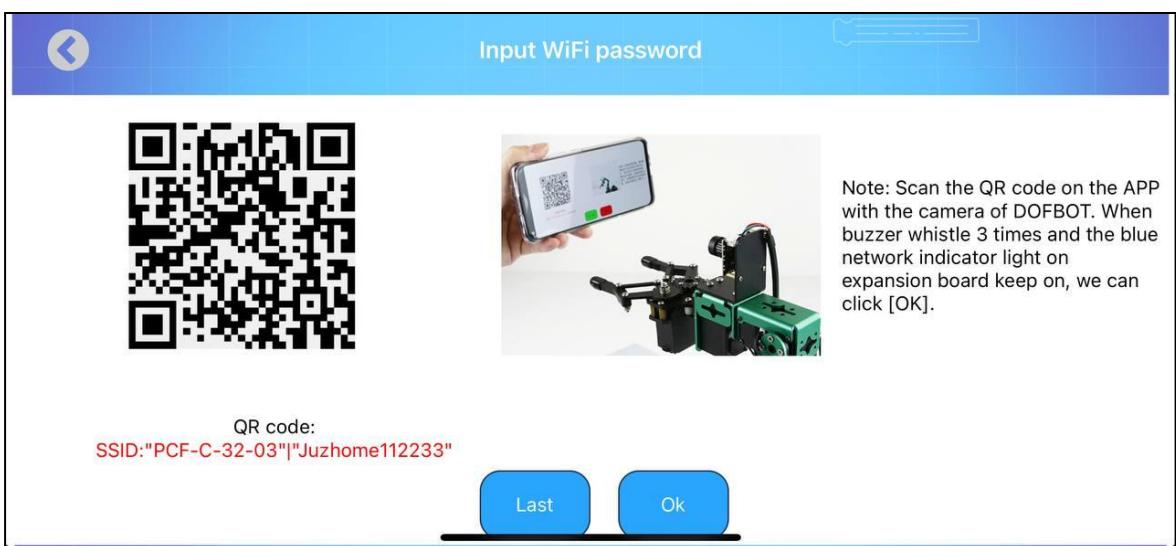
6. Give permission to access location.



7. Follow the instructions and be aware of the “Note”. Click “WiFi” to choose which WiFi to connect to. After entering the WiFi password, click “Connect”.



8. A QR code will be generated. Place the QR code about 20cm in front of the camera. Wait for the robot to whistle 3 times (network connection complete). Click “OK”.

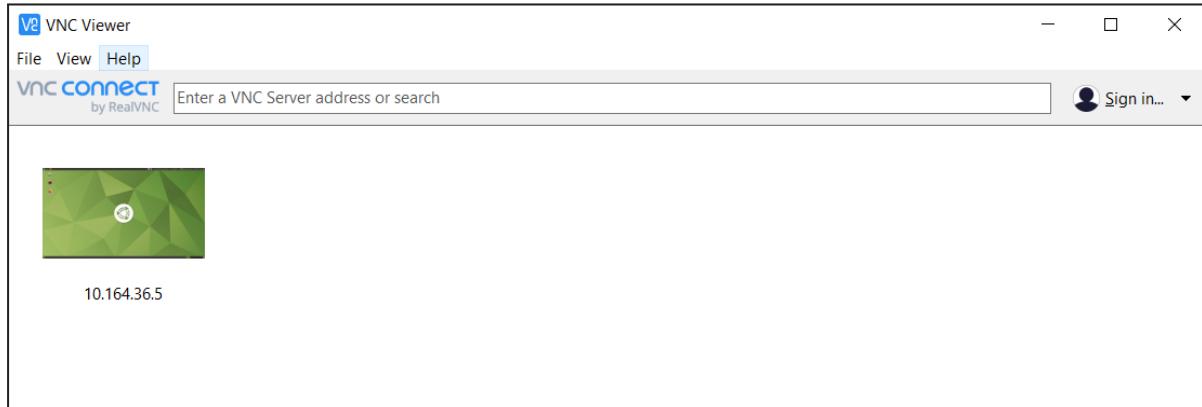


9. OLED will show the IP address based on your wifi connection.

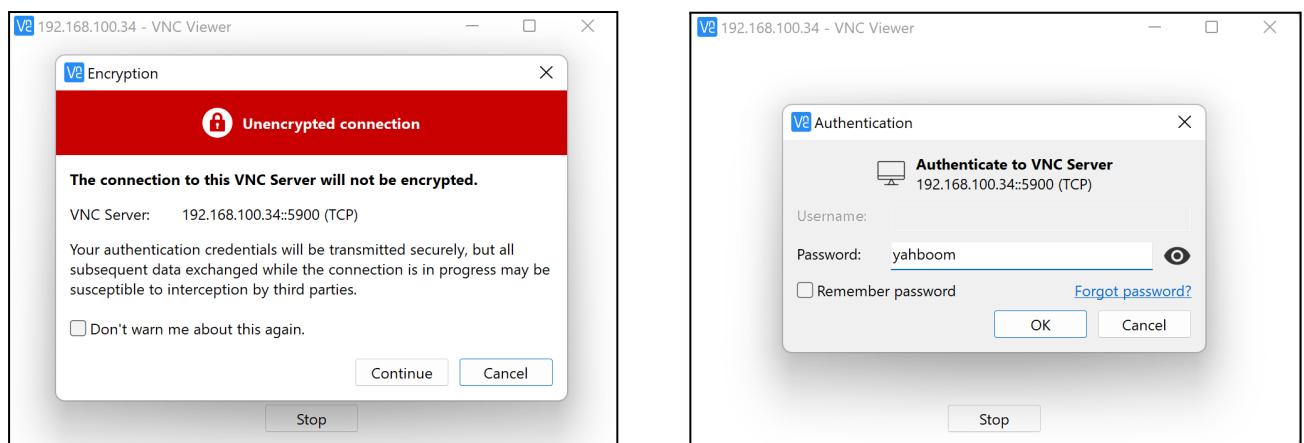


Connect laptop to robot Ubuntu system using VNC Viewer

1. On your laptop, install the VNC Viewer application.
2. Open VNC Viewer.



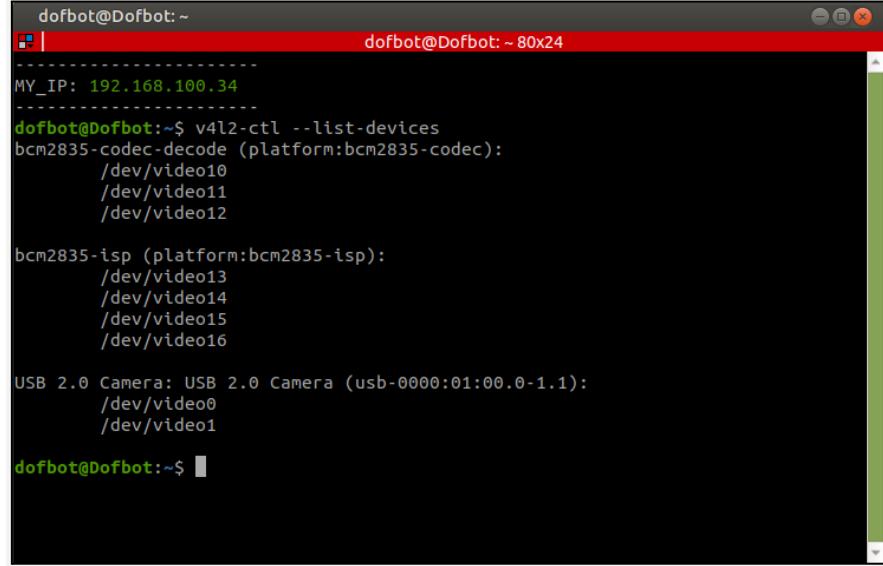
3. Enter the IP address “192.168.100.34” shown on the robot’s OLED.
4. A window will pop out showing the screen of the Ubuntu system. Press the continue and type in the password “yahboom” to enter the raspberry pi system.



Run the program

1. Open terminal.
2. Check the camera index. Ensure USB Camera is /dev/video0 and /dev/video1.

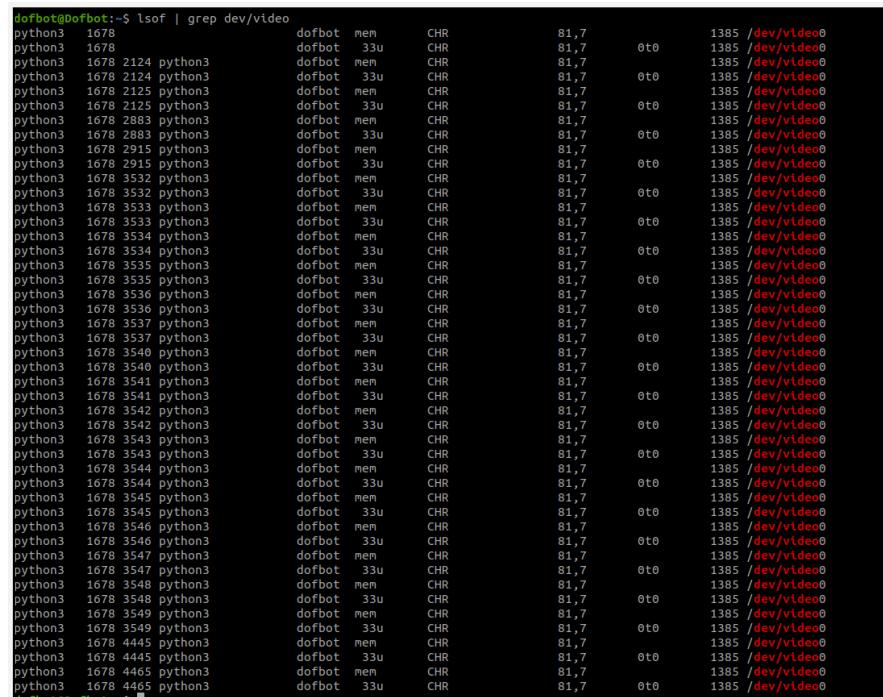
```
v4l2-ctl --list-devices
```



A screenshot of a terminal window titled "dofbot@Dofbot: ~". The window shows the command "v4l2-ctl --list-devices" being run. The output lists various camera devices:
MY_IP: 192.168.100.34
bcm2835-codec-decode (platform:bcm2835-codec):
/dev/video0
/dev/video11
/dev/video12
bcm2835-isp (platform:bcm2835-isp):
/dev/video13
/dev/video14
/dev/video15
/dev/video16
USB 2.0 Camera: USB 2.0 Camera (usb-0000:01:00.0-1.1):
/dev/video0
/dev/video1

3. Check if the camera is in use. Diagram below shows /dev/video0 is in use by job id 1385.

```
lsof | grep dev/video
```



A screenshot of a terminal window titled "dofbot@Dofbot: ~". The window shows the command "lsof | grep dev/video" being run. The output lists multiple processes (all named "dofbot") that have "/dev/video0" open, each associated with a job ID of 1385.
python3 1678 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 2124 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 2124 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 2125 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 2125 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 2883 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 2883 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 2915 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 2915 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3532 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3532 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3533 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3533 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3534 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3534 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3535 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3535 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3536 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3536 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3537 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3537 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3540 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3540 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3541 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3541 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3542 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3542 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3543 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3543 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3544 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3544 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3545 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3545 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3546 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3546 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3547 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3547 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3548 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3548 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 3549 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 3549 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 4445 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 4445 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0
python3 1678 4465 python3 dofbot mem CHR 81,7 0t0 1385 /dev/video0
python3 1678 4465 python3 dofbot 33u CHR 81,7 0t0 1385 /dev/video0

- 3.1 If there are processes that are using the camera, kill that process.

```
kill -9 <job_id> From the diagram above, the command is kill -9 1385.
```

4. Check if there is a rosnode running.

```
rosnode list
```

- 4.1 If there are rosnode running, kill all rosnode.

```
killall --exact roslaunch  
killall -exact rosrun  
rosnode kill -a
```

5. Go to the directory containing the bash script.

```
cd dofbot_ws/src/dofbot_moveit/scripts
```

6. Program running.

- 6.1 Whole program from bin detection to garbage classification and arm grasping

```
./run.sh
```

- 6.2 Only bin detection

```
./detection_bin.sh
```

- 6.3 Only garbage classification and arm grasping

```
./detection_garbage.sh
```

Code modification/explanation/execution

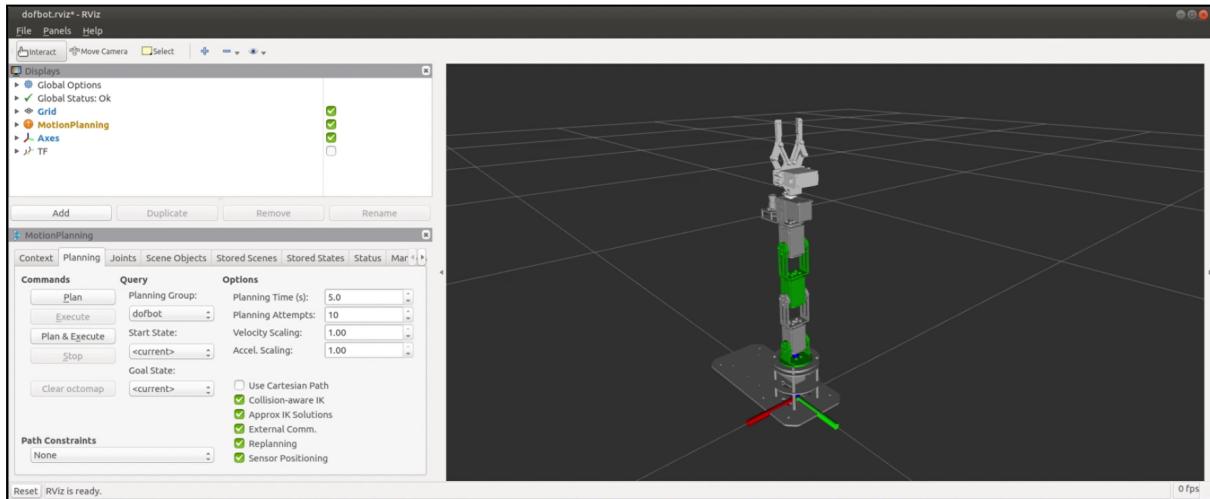
1. Arm manipulation

Control and determine the first five joints of Dofbot for moving to garbage and bin (not including the gripper)

The dofbot_ws/src/dofbot_moveit/scripts folder contains the code needed to perform arm control. In the terminal :

- Launch Rviz. Wait until “Rviz is ready” (shown at the bottom left of the Rviz window).
- Another window also pops out showing the slider of joint states. There are only 5 joints that can be controlled (joint 1 - joint 5), not including the gripper (joint 6).

```
roslaunch dofbot_config demo.launch
```



- Create a subscriber python file that subscribes to the topic in real-time and drive the robotic arm to move in real-time. The code is in the path `dofbot_ws/src/dofbot_moveit/scripts/00_dofbot_move.py`.

*Note: The gripper does not participate in the positive and negative solution of the movement, it needs to be controlled separately. However, do not set the 6th joint to 0°.

```

1  #!/usr/bin/env python3
2  # coding: utf-8
3
4  import rospy
5  import Arm_Lib
6  from math import pi
7  from sensor_msgs.msg import JointState
8
9  RA2DE = 180 / pi
10
11
12 def topic(msg): # Create a subscriber callback function
13
14     if not isinstance(msg, JointState): return
15
16     # Define the joint angle container, the last one is the angle of the gripper.
17     # Gripper needs to be controlled separately. Do not set the No.6 servo to 0°.
18     joints = [0.0, 0.0, 0.0, 0.0, 0.0, 90.0]
19
20     # Convert the received angle in radian [-1.57,1.57] to degree [0,180]
21     for i in range(5): joints[i] = (msg.position[i] * RA2DE) + 90
22
23     sbus.Arm_serial_servo_write6_array(joints, 100)
24
25
26 if __name__ == '__main__':
27     sbus = Arm_Lib.Arm_Device()
28     rospy.init_node("ros_dofbot")
29     # Create a subscriber
30     subscriber = rospy.Subscriber("/joint_states", JointState, topic)
31     rate = rospy.Rate(2)
32     rospy.spin()
```

- In a new terminal, run the python file.

```
rosrun dofbot_moveit 00_dofbot_move.py
```

After running the command, the arm will be initialized according to the values in the joint angle container.

You can change the value by moving the slider. The arm movement is shown in the Rviz window as well as in real-time on the robot.

* Using this slider can help you to determine the values of each joint to move to the garbage and the bin. Then, you can insert the value in the `arm_move_*.py` file to perform your task. For example, in `move_down()` of `arm_move_down.py`.

```
dofbot.set_joint_value_target([0.00,-0.95,-0.36,-1.57,-0.00])
```

- You can view the topic joint/states using the command below.
 - List all the ROS topics to determine whether /joint_states topic exists.
- ```
rostopic list
```
- Display the information of /joint\_states topic. The “position” shows the joint state value in radian.
- ```
rostopic echo /joint_states
```

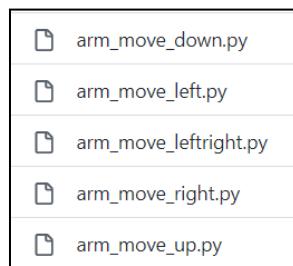
```
header:
  seq: 1278
  stamp:
    secs: 1675361686
    nsecs: 274427890
  frame_id: ''
name:
- joint1
- joint2
- joint3
- joint4
- joint5
position: [0.0, 0.0, 0.0, 0.0, -0.00015708000000014266]
velocity: []
effort: []
...
header:
  seq: 1279
  stamp:
    secs: 1675361686
    nsecs: 374441623
  frame_id: ''
name:
- joint1
- joint2
- joint3
- joint4
- joint5
position: [0.0, 0.0, 0.0, 0.0, -0.00015708000000014266]
velocity: []
effort: []
...
```

Run the arm movement to move to garbage or bin (not including the gripper)

The dofbot_ws/src/dofbot_moveit/scripts folder contains the code needed to perform arm control. These files are used to perform different arm movements. Gripper is ignored. To run these files, you must have Rviz running first. Then, choose which movement you want and run the corresponding file. For example, to let the arm move to the middle downwards.

To open Rviz: `roslaunch dofbot_config demo.launch`

New terminal: `rosrun dofbot_moveit arm_move_down.py`



Run the gripper of the arm to grasp objects (not including the other 5 joints)

The `dofbot/src/dofbot_moveit/src/scripts/` folder contains the code needed to perform gripper control. To run these files, you must have Rviz running first.

* Note: The subscriber node must be run before the publisher node.

To open Rviz: `rosrun dofbot_config demo.launch`

New terminal: `rosrun dofbot_moveit gripper_subscriber.py`

New terminal: `rosrun dofbot_moveit gripper_publisher.py`

```
gripper_publisher.py  
gripper_subscriber.py
```

The ROS topic named “`gripper_topic`” is used in the publisher and subscriber node to communicate the message.

- Create a subscriber for gripper.

```
sub = rospy.Subscriber('gripper_topic', Float64, gripper_callback)
```

Create a gripper subscriber callback function to receive the gripper position message and perform gripper action on the arm in real-time.

```
gripper_position = msg.data  
sbus.Arm_serial_servo_write(6, gripper_position, 1000)
```

- Create a publisher for gripper.

```
15     # Create the publisher object  
16     pub = rospy.Publisher('gripper_topic', Float64, queue_size=10)  
17  
18     # Read the angle of joint 6 (gripper)  
19     msg = Float64()  
20     angle = sbus.Arm_serial_servo_read(6)  
21     print("Angle=", angle)
```

Determine to open or close the gripper and the corresponding degree value. You may change the angle values which suits your use.

```
23     # Make sure the angle is not None before using it in the calculation  
24     if angle is not None:  
25         if angle <= 60.0: # If gripper is open  
26             msg.data = 140.0 # Close the gripper  
27         elif angle > 60.0 and angle <= 180.0: # If gripper is close  
28             msg.data = 30.0 # Open the gripper  
29     else:  
30         # Handle the case where the angle is None  
31         print("Error: Angle is not defined")
```

2. Garbage classification

The `dofbot_ws/src/dofbot_moveit/src` folder contains the code needed to perform garbage detection and classification. In the directory `dofbot_ws/src/dofbot_moveit/src/yolov5`, install the requirements of the YOLOv5 model.

```
pip3 install -r requirements.txt
```

📁 __pycache__	Add yolov5 files
📁 data	Add yolov5 files
📁 models	Add yolov5 files
📁 utils	Add yolov5 files
📄 CONTRIBUTING.md	Add yolov5 files
📄 Dockerfile	Add yolov5 files
📄 LICENSE	Add yolov5 files
📄 best.pt	Add yolov5 files
📄 detect.py	Add yolov5 files
📄 export.py	Add yolov5 files
📄 hubconf.py	Add yolov5 files
📄 requirements.txt	Add yolov5 files
📄 setup.cfg	Add yolov5 files
📄 train.py	Add yolov5 files
📄 tutorial.ipynb	Add yolov5 files
📄 val.py	Add yolov5 files

* Note: The garbage classification is using another `detect.py` file in the directory `dofbot_ws/src/dofbot_moveit/src`, not the `detect.py` file in the directory `dofbot_ws/src/dofbot_moveit/src/yolov5`. This is because the `detect.py` file in the directory `dofbot_ws/src/dofbot_moveit/src` has made some changes to implement the YOLOv5 model in ROS.

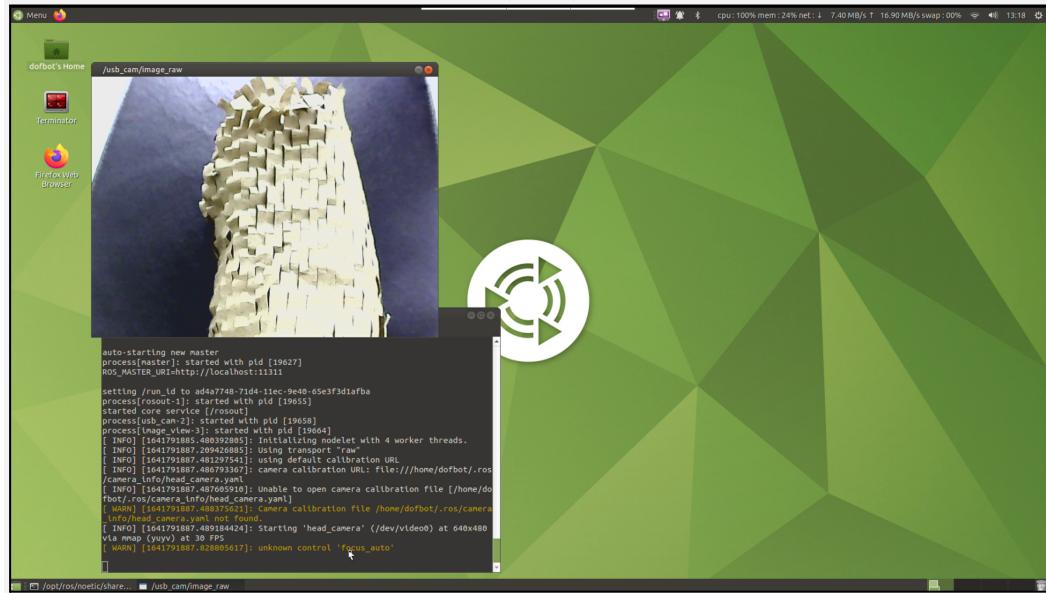
```
39  class Yolov5Detector:  
40      def __init__(self):  
41          self.conf_thres = rospy.get_param("~confidence_threshold")  
42          self.iou_thres = rospy.get_param("~iou_threshold")  
43          self.agnostic_nms = rospy.get_param("~agnostic_nms")  
44          self.max_det = rospy.get_param("~maximum_detections")
```

All the initialization value of the parameters is obtained from `dofbot_ws/src/dofbot_moveit/launch/yolov5.launch` using `rospy.get_param()` function.

To perform garbage classification

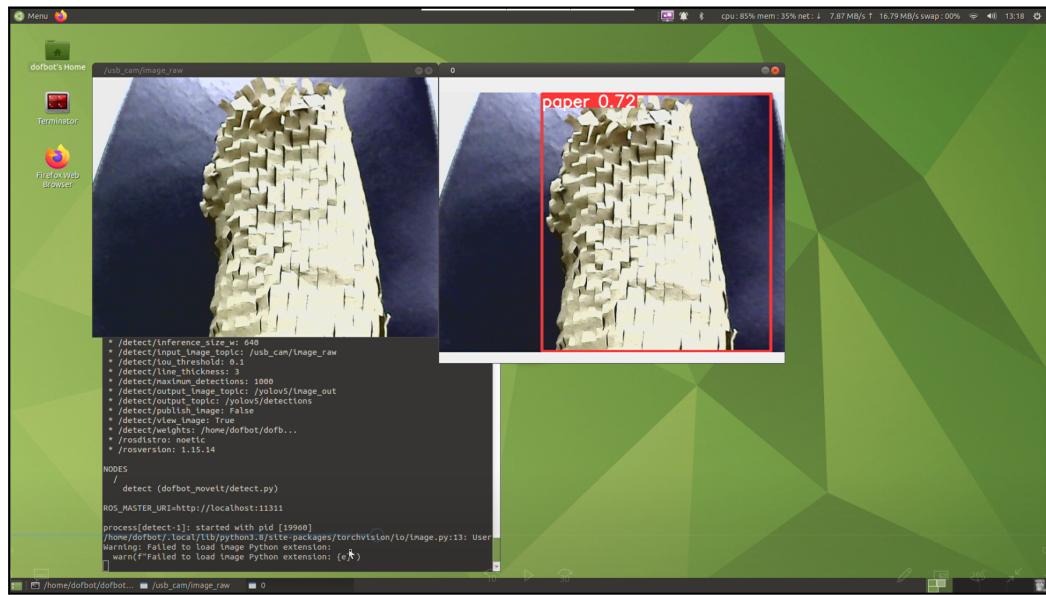
- Open a terminal, bring up the usb camera. Remember to check the camera index and if camera is in use.

```
roslaunch usb_cam usb_cam-test.launch
```

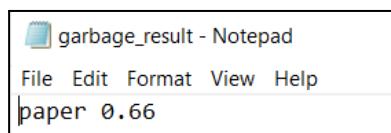


- In a new terminal, run the yolov5 model.

```
roslaunch dofbot_moveit yolov5.launch
```



- The result containing the type of garbage and the score is saved in a text file.



To train new garbage classification model

Go to the github link, refer to YOLOv5_Custom_Training.ipynb. You may directly open the code by clicking the “Open in Colab” button.



```
In [ ]: # clone YOLOv5 and
git clone https://github.com/ultralytics/yolov5 # clone repo
%cd yolov5
%pip install -qr requirements.txt # install dependencies
%pip install -q roboflow

import torch
import os
from IPython.display import Image, clear_output # to display images

print(f"Setup complete. Using torch {torch.__version__} ({torch.cuda.get_device_properties(0).name if torch.cuda.is_available() else 'CPU'})")

Cloning into 'yolov5'...
remote: Enumerating objects: 14936, done.
remote: Total 14936 (delta 0), reused 0 (delta 0), pack-reused 14936
```

To change the weight file and data configuration file

If you trained a new YOLOv5 model, either new weights or more type of recyclable garbage dataset, you can replace the .pt file and add the data in data.yaml file.

- The current weight used is best.pt. It is stored in the path dofbot_ws/src/dofbot_moveit/src/yolov5.
- The data.yaml file is in the path dofbot_ws/src/dofbot_moveit/src/yolov5/data. You may change the “nc” (number of classes for detection) and add the type of garbage in “names”.

```
1 nc: 2
2 names: ['Paper', 'Plastic']
```

To change the parameters of garbage classification

- `cd dofbot_ws/src/dofbot_moveit/launch/yolov5.launch`
- As shown in the figure below is a part of the `yolov5.launch` file. It specifies the path to weights and data configuration. Besides, you may change the value of `confidence_threshold`, `iou_threshold`, `inference_size` and other parameters which suit your requirement.
- You may change the parameter for `input_image_topic` in to any ROS topic with message type of `sensor_msgs/Image` or `sensor_msgs/CompressedImage`. In our case is using `ros-noetic-usb-cam` package. So, the “`input_image_topic`” is `"/usb_cam/image_raw"`

```
1 <launch>
2   <!-- Detection configuration -->
3   <arg name="weights"           default="$(find dofbot_moveit)/src/yolov5/best.pt"/>
4   <arg name="data"             default="$(find dofbot_moveit)/src/yolov5/data/data.yaml"/>
5   <arg name="confidence_threshold" default="0.50"/>
6   <arg name="iou_threshold"     default="0.1"/>
7   <arg name="maximum_detections" default="1000"/>
8   <arg name="device"           default="cpu"/>
9   <arg name="agnostic_nms"     default="true"/>
10  <arg name="line_thickness"    default="3"/>
11  <arg name="dnn"              default="true"/>
12  <arg name="half"             default="false"/>
13
14  <!-- replace imgsz -->
15  <arg name="inference_size_h"  default="640"/>
16  <arg name="inference_size_w"  default="640"/>
17
18  <!-- Visualize using OpenCV window -->
19  <arg name="view_image"        default="true"/>
20
21  <!-- ROS topics -->
22  <arg name="input_image_topic" default="/usb_cam/image_raw"/>
23  <arg name="output_topic"      default="/yolov5/detections"/>
24
25  <!-- Optional topic (publishing annotated image) -->
26  <arg name="publish_image"    default="false"/>
27  <arg name="output_image_topic" default="/yolov5/image_out"/>
28
```

```

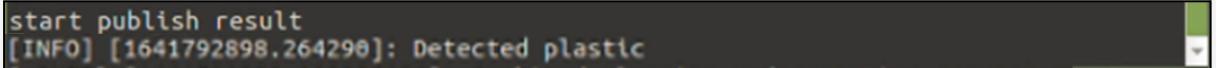
1   <launch>
2     <node name="usb_cam" pkg="usb_cam" type="usb_cam_node" output="screen" >
3       <param name="video_device" value="/dev/video0" />
4       <param name="image_width" value="640" />
5       <param name="image_height" value="480" />
6       <param name="pixel_format" value="yuyv" />
7       <param name="color_format" value="yuv422p" />
8       <param name="camera_frame_id" value="usb_cam" />
9       <param name="io_method" value="mmap"/>
10    </node>
11    <node name="image_view" pkg="image_view" type="image_view" respawn="false" output="screen">
12      <remap from="image" to="/usb_cam/image_raw"/>
13      <param name="autosize" value="true" />
14    </node>
15  </launch>

```

To publish result to robot arm to perform corresponding action:

The code is in the directory, dofbot_ws/src/dofbot_moveit/src/publish_result.py

```
rosrun dofbot_moveit publish_result.py
```



```

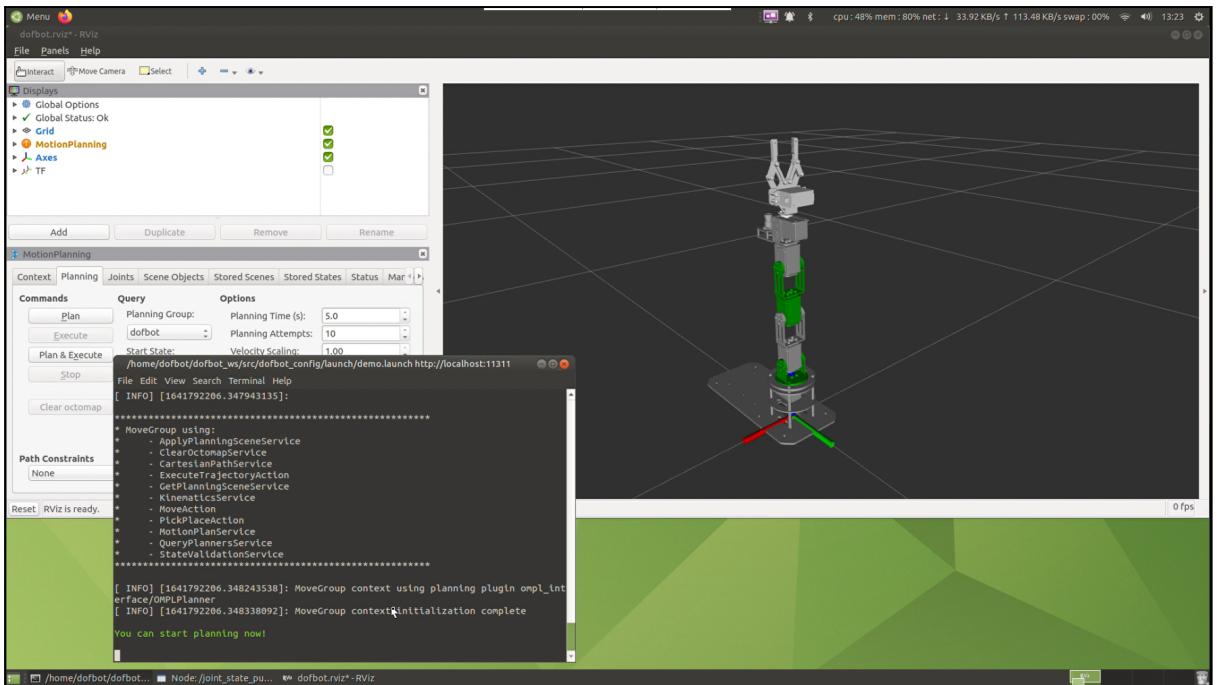
start publish result
[INFO] [1641792898.264290]: Detected plastic

```

To subscribe result from garbage classification to perform corresponding action:

* Note: The subscriber node must be run before the publisher node.

- To enable the robot arm movement, it must subscribe to the joint states from rviz. Running `demo.launch` is important as it will publish joint states through rviz. Then, the `arm_move_*.py` will subscribe to the joint states publisher and publish the desired values for each joint state to move to the bin.
- `roslaunch dofbot_config demo.launch`
- `rosrun dofbot_moveit arm_move_leftright.py`



```
/home/dofbot/dofbot_ws/src/dofbot_config/launch/demo.launch http://localhost:11311
File Edit View Search Terminal Help
start arm to move to bin
[ INFO] [1641792301.536191137]: Loading robot model 'dofbot'...
[ INFO] [1641792309.423280539]: Ready to take commands for planning group dofbot
Subscribed plastic
move to right
[ INFO] [1641792898.322024196]: Combined planning and execution request received
for MoveGroup action. Forwarding to planning and execution pipeline.
[ INFO] [1641792898.322482893]: Planning attempt 1 of at most 5
[ INFO] [1641792898.325956249]: Planner configuration 'dofbot' will use planner
'geometric::RRTConnect'. Additional configuration parameters will be set when th
e planner is constructed.
```

3. Bin classification

The dofbot_ws/src/dofbot_moveit/src/bin_detect.py file contains the code needed to perform bin detection and classification.

To setup bin classification:

- `pip3 install pytesseract`
- `sudo apt-get install tesseract-ocr`
- In terminal, type “`which pytesseract`” to find the installed path of pytesseract
- Ensure the pytesseract installation path and camera index are correct

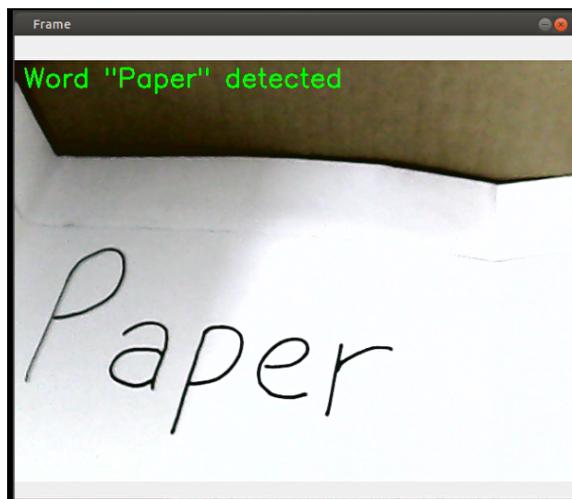
```
#!/usr/bin/env python3
import rospy
from std_msgs.msg import String
import cv2
import pytesseract

def bin_node():
    # Set the Tesseract path
    pytesseract.pytesseract.tesseract_cmd = "/usr/bin/tesseract"

    # Capture the main image
    capture = cv2.VideoCapture(0)
```

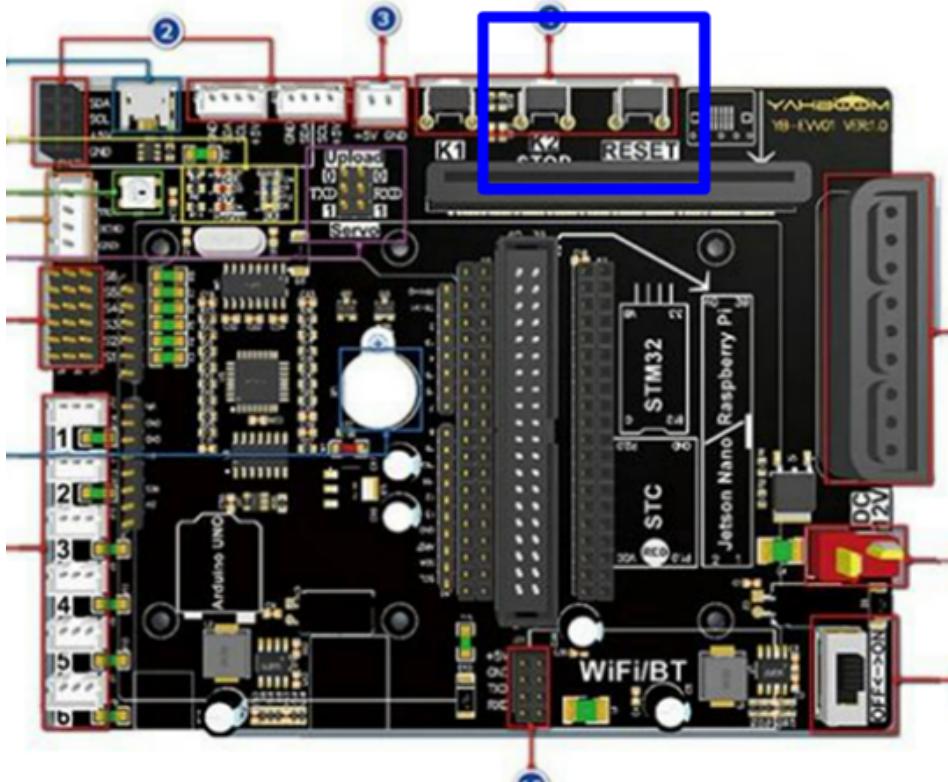
To perform bin classification:

- `rosrun dofbot_moveit bin_detect.py`



Error handling

1. If the robot is suddenly out of control, press the emergency 'stop' button on the robot.



2. If the system is lagging (the screen is changing slowly or the mouse cursor reacts very slow) or the roscore fails to run, kill the running processes.

```
roscore http://Dofbot:11311/
[roscore http://Dofbot:11311/]
[roscore http://Dofbot:11311/]
dofbot@Dofbot: ~
roscore http://Dofbot:11311/79x22
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://Dofbot:41621/
ros_comm version 1.15.14

SUMMARY
=====

PARAMETERS
* /rosdistro: noetic
* /rosversion: 1.15.14

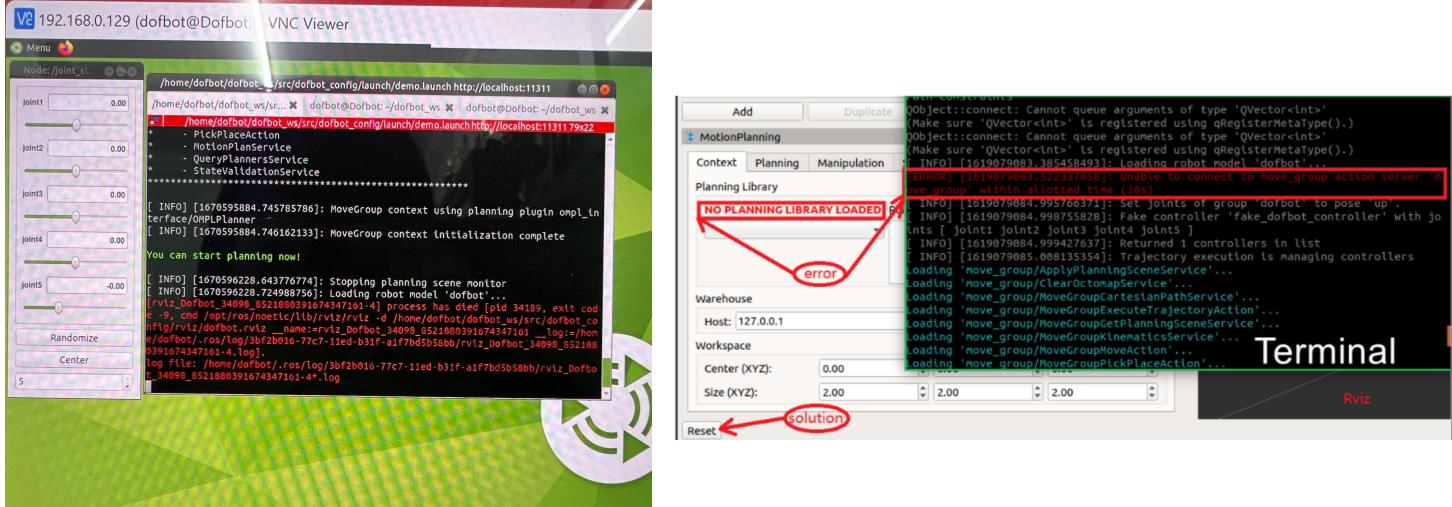
NODES

RLEception: roscore cannot run as another roscore/master is already running.
Please kill other roscore/master processes before relaunching.
The ROS_MASTER_URI is http://Dofbot:11311/
The traceback for the exception was written to the log file
dofbot@Dofbot:~$ killall -9 roscore
```

```
rosnode kill -a
killall --exact roslaunch
```

3. If the system freezed (the screen does not change for a few minutes or the mouse cursor does not react), restart the robot by power off and power on the robot.

4. Rviz Process has died and no planning library loaded



Click [Reset] and wait after loading. It is related to the performance of the device, and sometimes it takes a few more attempts or restarts.