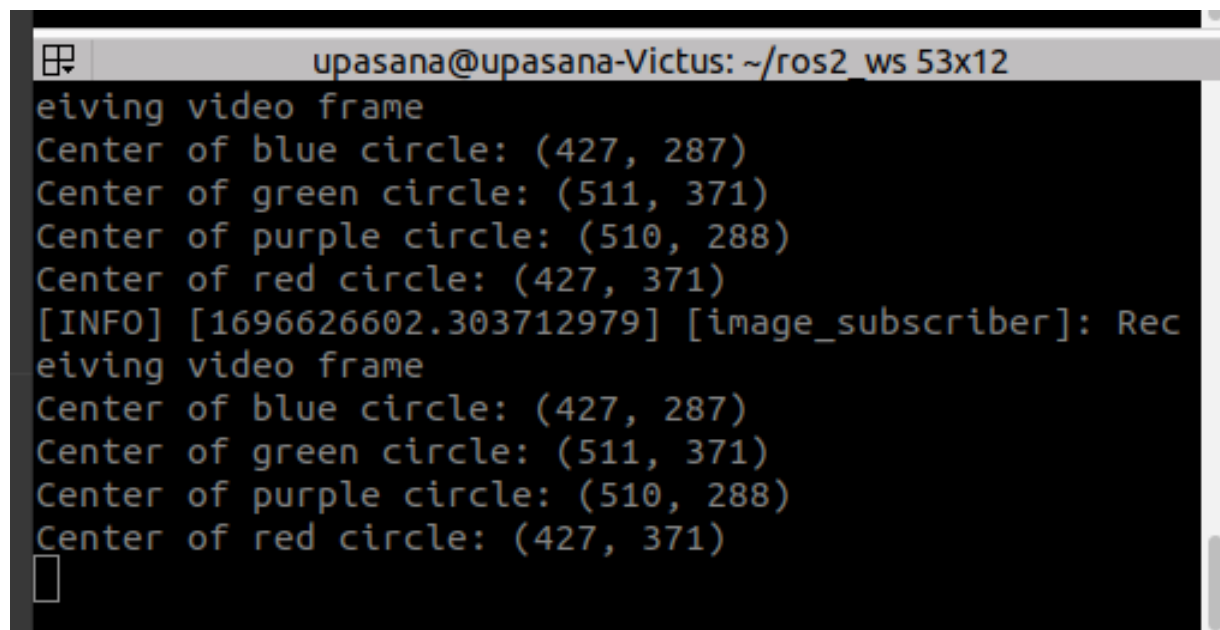
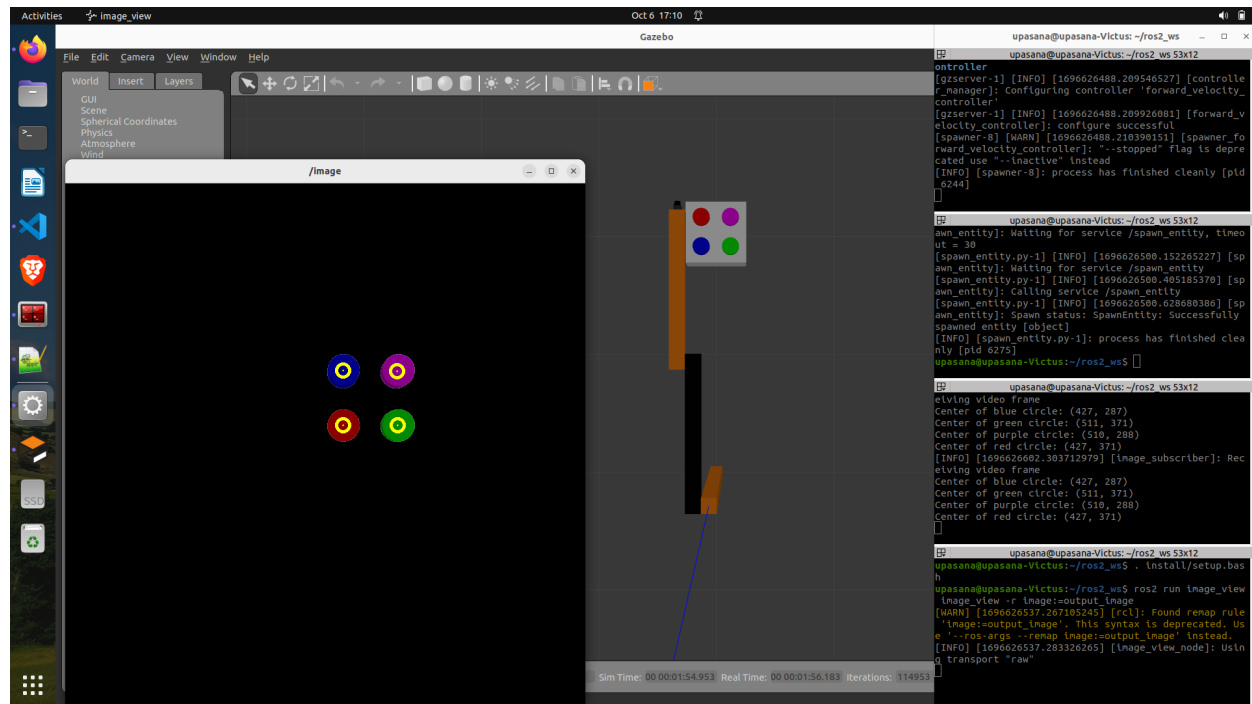


# RBE 450X – Homework 4

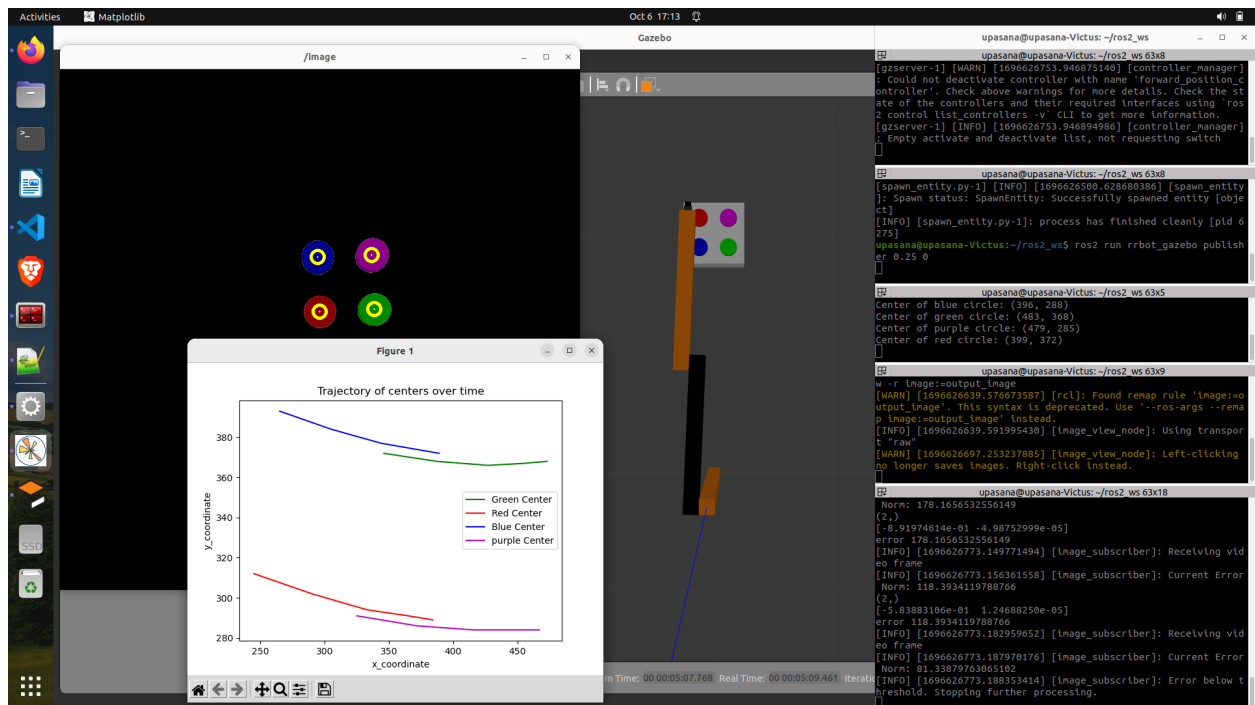
## Step 1 : Detect Circle Center





```
upasana@upasana-Victus: ~/ros2 ws 53x12
eiving video frame
Center of blue circle: (244, 312)
Center of green circle: (346, 372)
Center of purple circle: (325, 292)
Center of red circle: (265, 393)
[INFO] [1696626644.318288643] [image_subscriber]: Rec
eiving video frame
Center of blue circle: (245, 312)
Center of green circle: (346, 372)
Center of purple circle: (325, 292)
Center of red circle: (265, 393)
```

## Step 4: Visual Servoing Algorithm



## script.py :

```
script.py - ros2_ws - Visual Studio Code
File Edit Selection View Go Run Terminal Help

src> visual_servo > src> script.py > ImageSubscriber > findj > Imbda

1  #!/usr/bin/env python3
2  # Import the necessary libraries
3  import rclpy # Python library for ROS 2
4  from rclpy.node import Node # Handles the creation of nodes
5  from sensor_msgs.msg import Image # Image is the message type
6  from cv_bridge import CvBridge # Package to convert between ROS and OpenCV Images
7  import cv2 # OpenCV library
8  import numpy as np
9  from numpy.lib.function_base import average
10 import matplotlib.pyplot as plt
11 from tf2_ros import TransformException # Base class to handle exceptions
12 from tf2_ros.buffer import Buffer # Stores known frames and offers frame graph requests
13 from tf2_ros.transform_listener import TransformListener # Easy way to request and receive coordinate frame transform information
14 from std_msgs.msg import Float64MultiArray # Handle float64 arrays
15 #from tf.transformations import quaternion_matrix
16 from pyquaternion import Quaternion
17 #from tf2.transformations import quaternion_matrix
18 #from tf2_geometry_msgs import quaternion_matrix
19
20
21
22 class ImageSubscriber(Node):
23     """
24     Create an ImageSubscriber class, which is a subclass of the Node class.
25     """
26     def __init__(self):
27         """
28         Class constructor to set up the node
29         """
30         # Initiate the Node class's constructor and give it a name
31         super().__init__('image_subscriber')
32
33         # Create the subscriber. This subscriber will receive an Image
34         # from the video_frames topic. The queue size is 10 messages.
35
36         self.subscription = self.create_subscription(
37             Image,
38             '/camera/image_raw',
39             self.listener_callback,
40             10)
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script.py - ros2_ws - Visual Studio Code

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script.py
src > visual_servo > src > script.py > main
90
91 if A_sum < 10 and y_sum < 10:
92     return True
93 else:
94     return False
95
96 def plot(self,convergence,val):
97     if convergence:
98         plt.plot(self.gcx, self.gcy, color='g', label='Green Center')
99         plt.plot(self.rcx, self.rcy, color='r', label='Red Center')
100         plt.plot(self.bcx, self.bcy, color='b', label='Blue Center')
101         plt.plot(self.mcx, self.mcy, color='m', label='purple Center')
102         plt.xlabel('x coordinate')
103         plt.ylabel('y coordinate')
104         plt.legend()
105         plt.title("Trajectory of centers over time")
106         plt.show()
107         plt.savefig('plot.png')
108         rcpy.shutdown()
109         self.velocity_publisher.publish(val)
110
111 def masks(self,mask, img):
112     imask = mask>0
113     color = np.zeros_like(img, np.uint8)
114     color[imask] = img[imask]
115     return self.findCenters(mask, color)
116
117 def colorThreshold(self,img):
118
119     # Convert to HSV
120     hsv = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)
121
122     # Mask for each color
123     masks = {
124         "green": cv2.inRange(hsv, (36, 25, 25), (70, 255,255)),
125         "blue": cv2.inRange(hsv, (95, 25, 25), (135, 255,255)),
126         "red": cv2.inRange(hsv, (0, 100, 25), (15, 255,255)),
127         "purple": cv2.inRange(hsv, (140,100,20) , (170,255,255))
128     }
129
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH TERMINAL OUTPUT COMMENTS
upasana@upasana-Victus:~/ros2_ws$

x ROS2 humble 0.0.0 0.0 CMake [Debug] Ready No Kit Selected Build [all] Run CTest Share Code Link Blackbox Search Terminal Output Ln 311, Col 48 Spaces:2 UTF-8 LF Python 3.10.12 64-bit Blackbox
```

```
script.py - ros2_ws - Visual Studio Code

File Edit Selection View Go Run Terminal Help

script.py
src > visual_servo > src > script.py > ImageSubscriber > colorThreshold
134 cnts, _ = cv2.findContours(masks[color], cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
135 if cnts: # Check if any contour is detected
136     M = cv2.moments(cnts[0]) # Taking the first contour
137     if M["m00"] != 0: # Avoid division by zero
138         cx = int(M["m10"] / M["m00"])
139         cy = int(M["m01"] / M["m00"])
140         centers[color] = (cx, cy)
141     else:
142         centers[color] = (0, 0)
143
144
145 Code Suggestions
146
147 # Update your tracking lists
148 for color in self.color_order:
149     if color == "blue":
150         self.bcx.append(centers[color][0])
151         self.bcy.append(centers[color][1])
152     elif color == "green":
153         self.gcx.append(centers[color][0])
154         self.gcy.append(centers[color][1])
155     elif color == "red":
156         self.rcx.append(centers[color][0])
157         self.rcy.append(centers[color][1])
158     elif color == "purple":
159         self.mcx.append(centers[color][0])
160         self.mcy.append(centers[color][1])
161
162
163 # centers
164 self.bcx.append(centers["blue"][0])
165 self.bcy.append(centers["blue"][1])
166 self.gcx.append(centers["green"][0])
167 self.gcy.append(centers["green"][1])
168 self.mcx.append(centers["purple"][0])
169 self.mcy.append(centers["purple"][1])
170 self.rcx.append(centers["red"][0])
171 self.rcy.append(centers["red"][1])
172
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH TERMINAL OUTPUT COMMENTS
upasana@upasana-Victus:~/ros2_ws$

x ROS2 humble 0.0.0 0.0 CMake [Debug] Ready No Kit Selected Build [all] Run CTest Share Code Link Blackbox Search Terminal Output Ln 130, Col 47 Spaces:2 UTF-8 LF Python 3.10.12 64-bit Blackbox
```

```
script.py - ros2_ws - Visual Studio Code
File Edit Selection View Go Run Terminal Help
script.py
src > visual_servo > src > script.py > ImageSubscriber > colorThreshold
174
175 f_c = []
176 for color in self.color_order:
177     f_c.extend(centers[color])
178 f_c = np.array(f_c)
179
180 # Compute the error
181 # Compute the error
182 error = f_c - self.f_r
183 self.previous_error_norm = self.current_error_norm
184 self.current_error_norm = np.linalg.norm(error) # L2 norm of error
185 self.get_logger().info(f'Current Error Norm: {self.current_error_norm}')
186
187
188 # After computing the errors:
189 if self.current_error_norm < 100:
190     self.flag_below_threshold = True
191     val = Float64MultiArray()
192     val.data = [0.0, 0.0]
193     self.velocity_publisher.publish(val)
194     self.get_logger().info('Error below threshold. Stopping further processing.')
195     self.plot(True, val)
196     return
197
198
199
200
201 # Call the function to compute the Jacobian
202 try:
203     val=self.findJ(error)
204     self.velocity_publisher.publish(val)
205 except:
206     pass
207
208
209
210 print("error", self.current_error_norm)
211
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH TERMINAL OUTPUT COMMENTS
upasana@upasana-Victus:~/ros2_ws$
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```
script.py - ros2_ws - Visual Studio Code
File Edit Selection View Go Run Terminal Help
script.py
src > visual_servo > src > script.py > ImageSubscriber > colorThreshold
217
218 rotation_matrix[0, 0] = 1 - 2*y*y - 2*z*z
219 rotation_matrix[0, 1] = 2*x*y - 2*w*z
220 rotation_matrix[0, 2] = 2*x*z + 2*w*y
221
222 rotation_matrix[1, 0] = 2*x*y + 2*w*z
223 rotation_matrix[1, 1] = 1 - 2*x*x - 2*z*z
224 rotation_matrix[1, 2] = 2*y*z - 2*w*x
225
226 rotation_matrix[2, 0] = 2*x*z - 2*w*y
227 rotation_matrix[2, 1] = 2*y*z + 2*w*x
228 rotation_matrix[2, 2] = 1 - 2*x*x - 2*y*y
229
230 rotation_matrix[3, 3] = 1.0
231
232 return rotation_matrix
233
234
235 def findJ(self,error,lmbda = -0.001):
236     L_e_i = -1*np.eye(2)
237     L_e = np.vstack((L_e_i,L_e_i,L_e_i,L_e_i))
238     L_e_inv = np.linalg.pinv(L_e)
239     v_c = -lmbda*L_e_inv @ error
240     print(v_c.shape)
241     vc=[]
242
243     vc.append(v_c[0])
244     vc.append(v_c[1])
245     vc.append(0)
246     vc.append(1)
247     vc=np.array(vc,dtype=float)
248     v_c=vc
249
250
251 try:
252     now = rospy.time.Time()
253     trans = self.tf.buffer.lookup_transform("link1","camera_link",now)
254 except TransformException as ex:
255     self.get_logger().info(
256         f'Could not transform {"link1"} to {"camera_link"}: {ex}')
257     return
258
```

script.py - ros2\_ws - Visual Studio Code

File Edit Selection View Go Run Terminal Help

script.py

src > visual\_servo > src > script.py > ImageSubscriber > colorThreshold

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Code Suggestions

Comment Code

def main(args=None):  
 # Initialize the rclpy library  
 rclpy.init(args=args)  
 # Create the node  
 image\_subscriber = ImageSubscriber()  
 # Spin the node so the callback function is called.  
 rclpy.spin(image\_subscriber)  
 # Spin the node so the callback function is called.  
 # As you want to keep checking for a certain number of iterations or until the flag is set,  
 # you can replace rclpy.spin with a loop:  
 for \_ in range(10000):  
 rclpy.spin\_once(image\_subscriber)  
 if image\_subscriber.flag\_below\_threshold:  
 break  
 # Now, check the flag to decide the action:  
 if image\_subscriber.flag\_below\_threshold:  
 plt.show()  
 else:  
 print("Error never went below threshold.")  
 image\_subscriber.destroy\_node()  
 # Shutdown the ROS client library for Python  
 rclpy.shutdown()  
if \_\_name\_\_ == '\_\_main\_\_':  
 main()

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS SEARCH TERMINAL OUTPUT COMMENTS

upasana@upasana-Victus:~/ros2\_ws\$

ROS2\_humble 0.0.0 No Kit Selected Build [all] Run CTest Share Code Link Blackbox Search Terminal Output Ln 120, Col 47 Spaces: 2 UTF-8 LF Python 3.10.12 64-bit Blackbox