Wood block shape sorting

1. Content Description

This function enables the program to obtain images through the camera, identify the shape of the wooden block in the image according to the input target shape parameters, and clamp the wooden block of the target shape and place it at the set position.

This section requires entering commands in the terminal. The terminal you open depends on your motherboard type. This lesson uses the Raspberry Pi 5 as an example. For Raspberry Pi and Jetson-Nano boards, you need to open a terminal on the host computer and enter the command to enter the Docker container. Once inside the Docker container, enter the commands mentioned in this section in the terminal. For instructions on entering the Docker container from the host computer, refer to this product tutorial **[Configuration and Operation Guide]--[Enter the Docker (Jetson Nano and Raspberry Pi 5 users, see here)]**.

Simply open the terminal on the Orin motherboard and enter the commands mentioned in this section.

2. Program startup

First, open the terminal and enter the following command to start the robot arm solver and camera driver,

```
ros2 launch M3Pro_demo camera_arm_kin.launch.py
```

Then, open another terminal and enter the following command to start the robotic arm gripping program:

```
ros2 run M3Pro_demo grasp_desktop
```

```
root@raspberrypi:~# ros2 run M3Pro_demo grasp_desktop
{'x_offset': 0.009194198105858475, 'y_offset': 0.008621797965265302, 'z_offset'
: -0.0177}
---------------------------
x_offset:  0.009194198105858475
y_offset:  0.008621797965265302
z_offset:  -0.0177
----------------------
init done
self.CurEndPose:  [0.15326204031848129, 0.00021945213146852945, 0.3441362743447
702, 6.061238269342215e-05, -0.03490672896787105, -2.909509128997985e-05]
```

Finally, open the third terminal and enter the following command to start the wood block shape sorting program:

```
ros2 run M3Pro_demo shape_recognize
```

After starting this command, the second terminal should receive the current angle topic information sent in one frame and calculate the current posture once, as shown in the figure below.

```
root@raspberrypi:~/yahboomcar_ws# ros2 run M3Pro_demo shape_recognize
{'x_offset': 0.009194198105858475, 'y_offset': 0.008621797965265302, 'z_offset'
: -0.0277}
----------------------------
x_offset:  0.009194198105858475
y_offset:  0.008621797965265302
z_offset:  -0.0277
init done
{'x_offset': 0.009194198105858475, 'y_offset': 0.008621797965265302, 'z_offset'
: -0.0277}
----------------------------
x_offset:  0.009194198105858475
y_offset:  0.008621797965265302
z_offset:  -0.0277
init done
----------------------
Init done.
Please enter a target shape, which can be selected from Rectangle  Square  Cyli
nder : Rectangle
```

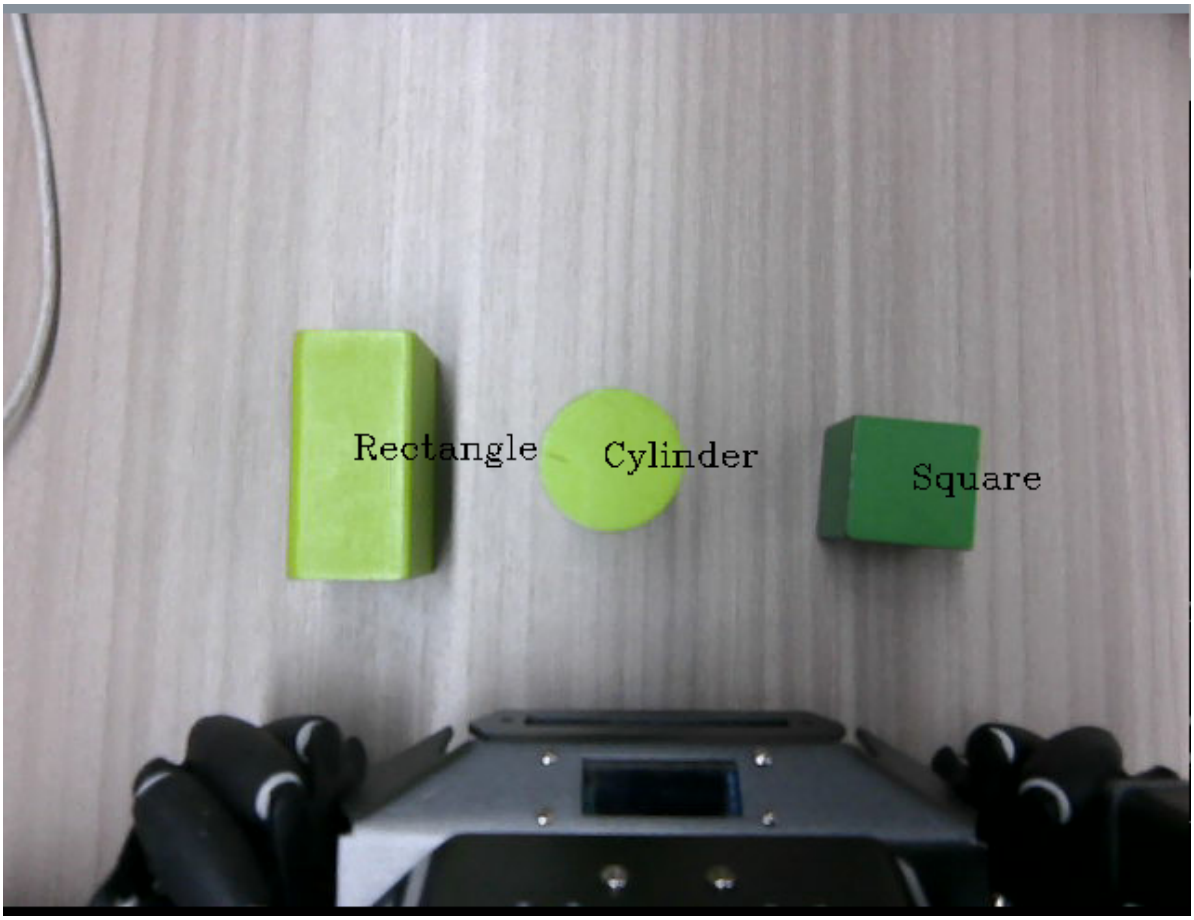
If the current angle information is not received and the current posture is not calculated, the gripping posture will be inaccurate when the coordinate system is converted. Therefore, you need to close the wood block shape sorting program by pressing ctrl+c and restart it again until the robot arm gripping program obtains the current angle information and calculates the current end position.

After the program is started, you need to enter the shape of the wooden blocks you want to sort in the terminal. There are three shapes: Rectangle, Square, and Cylinder. If we want to sort rectangular blocks, we need to enter: Rectangle, as shown in the figure below.

```
oot@raspberrypi:~# ros2 run M3Pro_demo grasp_desktop
{'x_offset': 0.009194198105858475, 'y_offset': 0.008621797965265302, 'z_offset'
 -0.0177}
----------------------------
_offset:  0.009194198105858475
_offset:  0.008621797965265302
_offset:  -0.0177
----------------------
[INFO] [1750820335.524877470] [Grasp_Node]: Service not available, waiting agai
...
init done
self.CurEndPose:  [0.15326204031848129, 0.00021945213146852945, 0.3441362743447
702, 6.061238269342215e-05, -0.03490672896787105, -2.909509128997985e-05]
array('h', [90, 120, 0, 0, 90, 90])
self.CurEndPose:  [0.1458589529828534, 0.00022969568906952754, 0.18566515428310
748, 0.00012389155580734876, 1.0471973953319513, 8.297829493472317e-05]
```

Terminal that starts the robotic arm gripping program

After pressing Enter, a color screen will appear. Then, press the spacebar to start gripping the block. The recognized block's shape will also appear on the screen. Calculate the distance between the recognized block and the car's base_link. If the distance is within [190, 210], directly lower the gripper to grip the block and place it at the set location. If the distance is outside [190, 210], control the chassis to move the block within [190, 210], then lower the gripper to grip the block and place it at the set location.



3. Core code analysis

Program code path:

- Raspberry Pi and Jetson-Nano board

  The program code is in the running docker. The path in docker is /root/yahboomcar_ws/src/M3Pro_demo/M3Pro_demo/ shape_recognize.py

- Orin Motherboard

  The program code path is /home/jetson/yahboomcar_ws/src/M3Pro_demo/M3Pro_demo/shape_recognize.py

Import the necessary library files,

```
import cv2
import os
import numpy as np
from cv_bridge import CvBridge
import cv2 as cv
from M3Pro_demo.Robot_Move import *
from arm_interface.srv import ArmKinemarics
from arm_interface.msg import AprilTagInfo,CurJoints
from arm_msgs.msg import ArmJoints
from std_msgs.msg import Float32,Bool,Int16
import time
import transforms3d as tfs
import tf_transformations as tf
import yaml
import math
from rclpy.node import Node
import rclpy
```

```
from message_filters import Subscriber,
TimeSynchronizer,ApproximateTimeSynchronizer
from sensor_msgs.msg import Image
from geometry_msgs.msg import Twist
from M3Pro_demo.compute_joint5 import *
```

Program initialization and creation of publishers and subscribers,

```
def __init__(self, name):
    super().__init__(name)
    self.init_joints = [90, 100, 0, 0, 90, 0]
    self.rgb_bridge = CvBridge()
    self.depth_bridge = CvBridge()
    self.pub_pos_flag = False
    #Define the array that stores the current end pose coordinates
    self.CurEndPos = [0.1279009179959246, 0.00023254956548456117,
0.1484898062979958, 0.00036263794618046863, 1.3962632350758744,
0.0003332603981328959]
    #Dabai_DCW2 camera internal parameters
    self.camera_info_K = [477.57421875, 0.0, 319.3820495605469, 0.0,
477.55718994140625, 238.64108276367188, 0.0, 0.0, 1.0]
    #Rotation matrix from the end to the camera
    self.EndToCamMat = np.array([[ 0 ,0 ,1 ,-1.00e-01],
                                 [-1  ,0 ,0  ,0],
                                 [0  ,-1  ,0 ,4.82000000e-02],
                                 [ 0.00000000e+00 , 0.00000000e+00 ,
0.00000000e+00 , 1.00000000e+00]])
    self.rgb_image_sub = Subscriber(self, Image, '/camera/color/image_raw')
    self.sub_grasp_status =
self.create_subscription(Bool,"grasp_done",self.get_graspStatusCallBack,100)
    self.depth_image_sub = Subscriber(self, Image, '/camera/depth/image_raw')
    self.CmdVel_pub = self.create_publisher(Twist,"cmd_vel",1)
    self.pub_cur_joints = self.create_publisher(CurJoints,"Curjoints",1)
    self.pos_info_pub = self.create_publisher(AprilTagInfo,"PosInfo",1)
    self.pub_SixTargetAngle = self.create_publisher(ArmJoints, "arm6_joints",
10)
    self.client = self.create_client(ArmKinemarics, 'get_kinemarics')
    self.TargetJoint5_pub = self.create_publisher(Int16, "set_joint5", 10)
    self.pubSixArm(self.init_joints)
    #Get the current robot arm end pose coordinates
    self.get_current_end_pos()
    self.pubCurrentJoints()
    self.ts = ApproximateTimeSynchronizer([self.rgb_image_sub,
self.depth_image_sub], 1, 0.5)
    self.ts.registerCallback(self.callback)
    #Define the target wood block shape
    self.Target_Shape = "Cylinder" #Rectangle  Square  Cylinder
    self.x_offset = offset_config.get('x_offset')
    self.y_offset = offset_config.get('y_offset')
    self.z_offset = offset_config.get('z_offset')
    self.adjust_dist = True
    self.linearx_PID = (0.5, 0.0, 0.2)
    self.linearx_pid = simplePID(self.linearx_PID[0] / 1000.0,
self.linearx_PID[1] / 1000.0, self.linearx_PID[2] / 1000.0)
    self.done_flag = True
    self.joint5 = Int16()
    self.corners = np.empty((4, 2), dtype=np.int32)
```

```
        self.valid_dist = True
        print("Init done.")
```

callback image topic callback function,

```
def callback(self,color_frame,depth_frame):
    #Get color image topic data and use CvBridge to convert message data into
image data
    rgb_image = self.rgb_bridge.imgmsg_to_cv2(color_frame,'rgb8')
    rgb_image = cv2.cvtColor(rgb_image, cv2.COLOR_RGB2BGR)
    result_image = np.copy(rgb_image)
    #Get color image topic data and use CvBridge to convert message data into
image data
    depth_image = self.depth_bridge.imgmsg_to_cv2(depth_frame, encoding[1])
    frame = cv.resize(depth_image, (640, 480))
    depth_to_color_image = cv2.applyColorMap(cv2.convertScaleAbs(depth_image,
alpha=1.0), cv2.COLORMAP_JET)
    depth_image_info = frame.astype(np.float32)
    #cv2.cvtColor converts the image from BGR to grayscale for subsequent image
processing
    gray_image = cv2.cvtColor(depth_to_color_image, cv2.COLOR_BGR2GRAY)
    #Create an all-zero array with exactly the same shape and data type as
gray_image
    black_image = np.zeros_like(gray_image)
    #Assign values to the array and copy the pixel values of the first 420 rows ×
the first 640 columns of the grayscale image to the same position in black_image
    black_image[0:400, 0:640] = gray_image[0:400, 0:640]
    #Threshold black_image and set all pixels with values < 90 to 0 (pure black)
    black_image[black_image < 90] = 0
    cv2.circle(black_image, (320,240), 1, (255,255,255), 1)


    gauss_image = cv2.GaussianBlur(black_image, (3, 3), 1)
    #Convert the grayscale image to a binary image (black and white image)
    _,threshold_img = cv2.threshold(gauss_image, 0, 255, cv2.THRESH_BINARY)
    #Perform corrosion operation on the image to remove noise
    erode_img = cv2.erode(threshold_img, np.ones((5, 5), np.uint8))
    #Dilution operation on the image to connect the broken edges
    dilate_img = cv2.dilate(erode_img, np.ones((5, 5), np.uint8))
    #Find the contour according to the image and perform shape analysis. The
returned contours are a list of contour points.
    contours, hierarchy = cv2.findContours(dilate_img, cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_NONE)
    #Traverse each contour point list
    for obj in contours:
        area = cv2.contourArea(obj)
        if area < 2000 :
            continue
        #Draw the contour function to visualize the detected object contours
        cv2.drawContours(depth_to_color_image, obj, -1, (255, 255, 0), 4)
        #Calculate the perimeter of the object
        perimeter = cv2.arcLength(obj, True)
        #Approximate the contour into a simpler polygon
        approx = cv2.approxPolyDP(obj, 0.035 * perimeter, True)
        self.corners = approx
        cv2.drawContours(depth_to_color_image, approx, -1, (255, 0, 0), 4)
       # Calculate the number of edges
```

```
        CornerNum = len(approx)
        #print(CornerNum)
        x, y, w, h = cv2.boundingRect(approx)
        if CornerNum == 3: objType = "triangle"
        elif CornerNum == 4:
            side_lengths = []
            for i in range(4):
                p1 = approx[i]
                p2 = approx[(i + 1) % 4]
                side_lengths.append(np.linalg.norm(p1 - p2))  # Calculate the
distance between two points
            #Calculate the length of adjacent edges
            side_lengths = np.array(side_lengths)
            #Judge the error of two adjacent sides. If the error is within the
range, the adjacent sides are considered equal, which is a square, otherwise it
is a rectangle
            if np.allclose(side_lengths[1], side_lengths[0], atol=50):  # Allow
some small errors
                objType = "Square"
            else:
                objType = "Rectangle"
            #According to actual needs, if the number of sides is greater than
5, it is considered a circle, that is, the top of the cylinder
        elif CornerNum > 5:
            objType = "Cylinder"
        else:
            objType = "None"
        rect = cv2.minAreaRect(obj)
        center = rect[0]
        key = cv2.waitKey(1)
        if key == 32:
            self.pub_pos_flag = True
            self.adjust_dist = True
        if self.pub_pos_flag == True:
            #If the shape of the currently detected wood block is the target
shape wood block and the last clamping and placement process is completed
            if objType == self.Target_Shape and self.done_flag == True:
                #Extract the center coordinates of the target shape
                cx = int(center[0])
                cy = int(center[1])
                #Calculate the depth information of the center point
                dist = depth_image_info[int(cy),int(cx)]/1000
                #Calculate the pose of the target shape block in the world
coordinate system
                pose = self.compute_heigh(cx,cy,dist)
                #Calculate the distance between the target shape block and the
car base_link
                dist_detect = math.sqrt(pose[1] ** 2 + pose[0]** 2)
                dist_detect = dist_detect*1000
                #If the distance is less than 13, modify the value of
self.valid_dist to False, indicating an invalid distance
                if dist_detect<130:
                    self.valid_dist = False
                    print("Invalid dist.Plese restart the program.")
                dist = 'dist: ' + str(dist_detect) + 'mm'
                cv.putText(rgb_image, dist, (int(cx)+5, int(cy)+15),
cv.FONT_HERSHEY_SIMPLEX, 0.5, (255, 0, 0), 2)
```

```
                #If the distance is outside the range [190, 210], and chassis
adjustment is enabled and the distance is a valid distance, then call the
self.move_dist function to control the chassis adjustment distance
                if abs(dist_detect - 200.0)>10 and self.adjust_dist==True and
self.valid_dist == True:
                    self.move_dist(dist_detect)
                #If the distance is within the interval [190, 210] and the
distance is valid, then sort out the location information of the target shape and
then publish the message
                elif abs(dist_detect - 200.0)<10 and self.valid_dist == True:
                    self.pubVel(0,0,0)
                    self.adjust_dist = False
                    cx = int(center[0])
                    cy = int(center[1])
                    dist = depth_image_info[int(cy),int(cx)]/1000
                    print("dist: ",dist)
                    if dist!=0:
                        vx = self.corners[0][0][0] - self.corners[1][0][0]
                        vy = self.corners[0][0][1] - self.corners[1][0][1]
                        target_joint5 = compute_joint5(vx,vy)
                        self.joint5.data = int(target_joint5)
                        pos = AprilTagInfo()
                        pos.x = float(cx)
                        pos.y = float(cy)
                        pos.z = float(dist)
                        if self.pub_pos_flag == True:
                            self.pub_pos_flag = False
                            self.done_flag = False
                            self.pos_info_pub.publish(pos)
                            self.TargetJoint5_pub.publish(self.joint5)
            cv2.circle(rgb_image, (int(center[0]),int(center[1])), 5,
(0,255,255), 5)
        cv2.putText(rgb_image, objType, (x + w // 2, y + (h //2)),
cv2.FONT_HERSHEY_COMPLEX, 0.6, (0, 0, 0), 1)

    cv2.imshow("depth_to_color_image", depth_to_color_image)
    cv2.imshow("rgb_image", rgb_image)
    key = cv2.waitKey(10)
```