Sorting height abnormality machine code

1. Content Description

This function allows the program to acquire an image through the camera and identify the machine code in the image, calculate the height of each machine code, and then remove the machine code with a height higher than 4 cm.

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

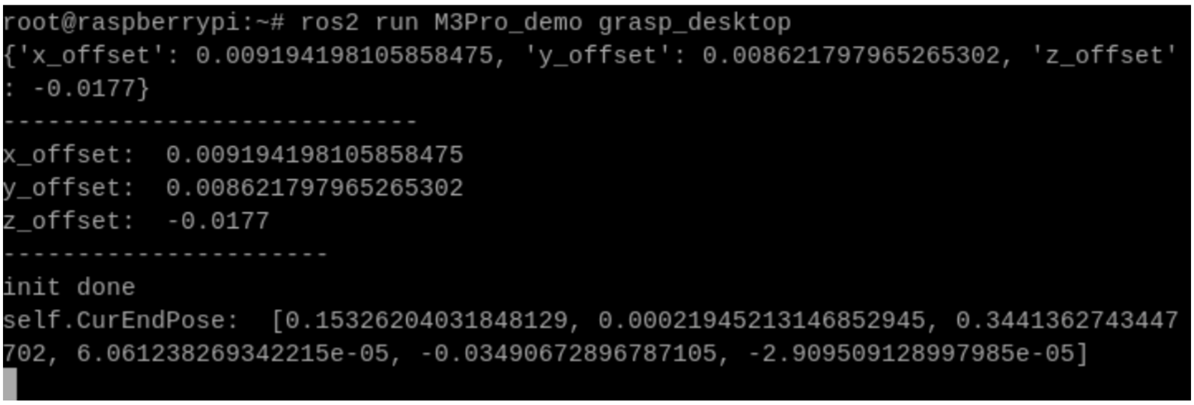
First, open the terminal and enter the following command to start the robot arm solver and camera driver,

```
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
```

After running, it is shown as follows:

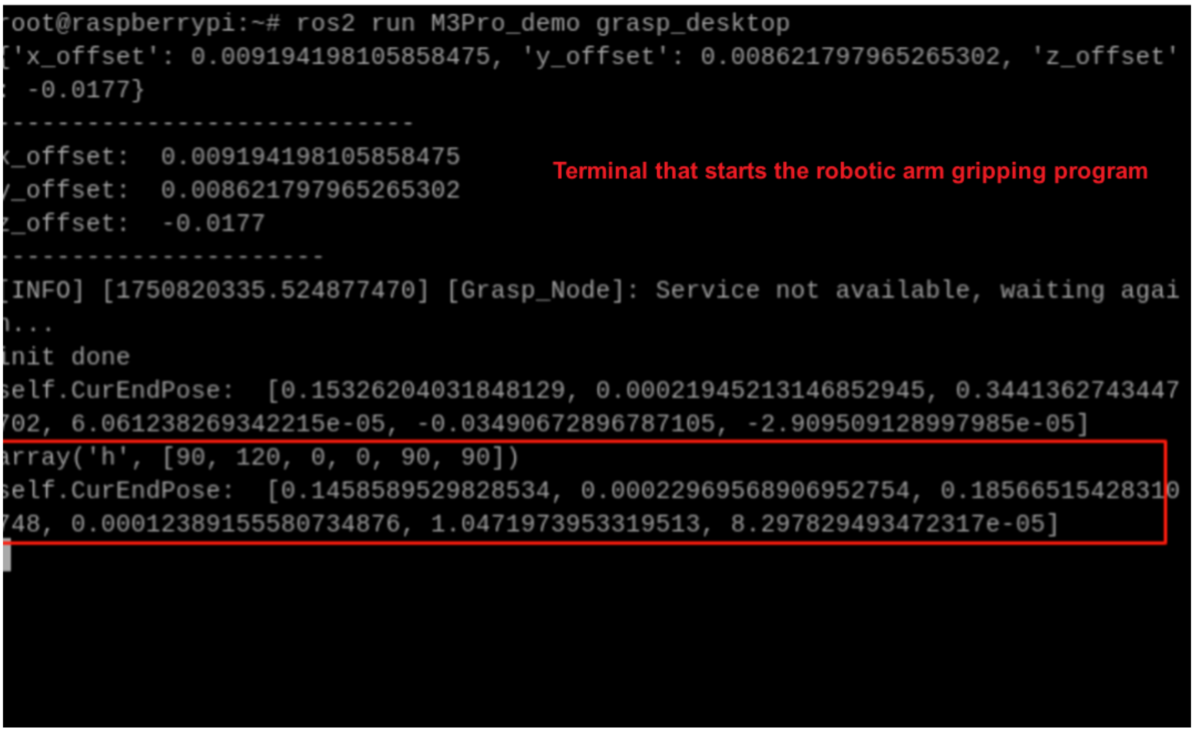


Finally, open the third terminal and enter the following command to start the program to remove highly abnormal machine code:

```
ros2 run M3Pro_demo apriltag_list
```

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 below

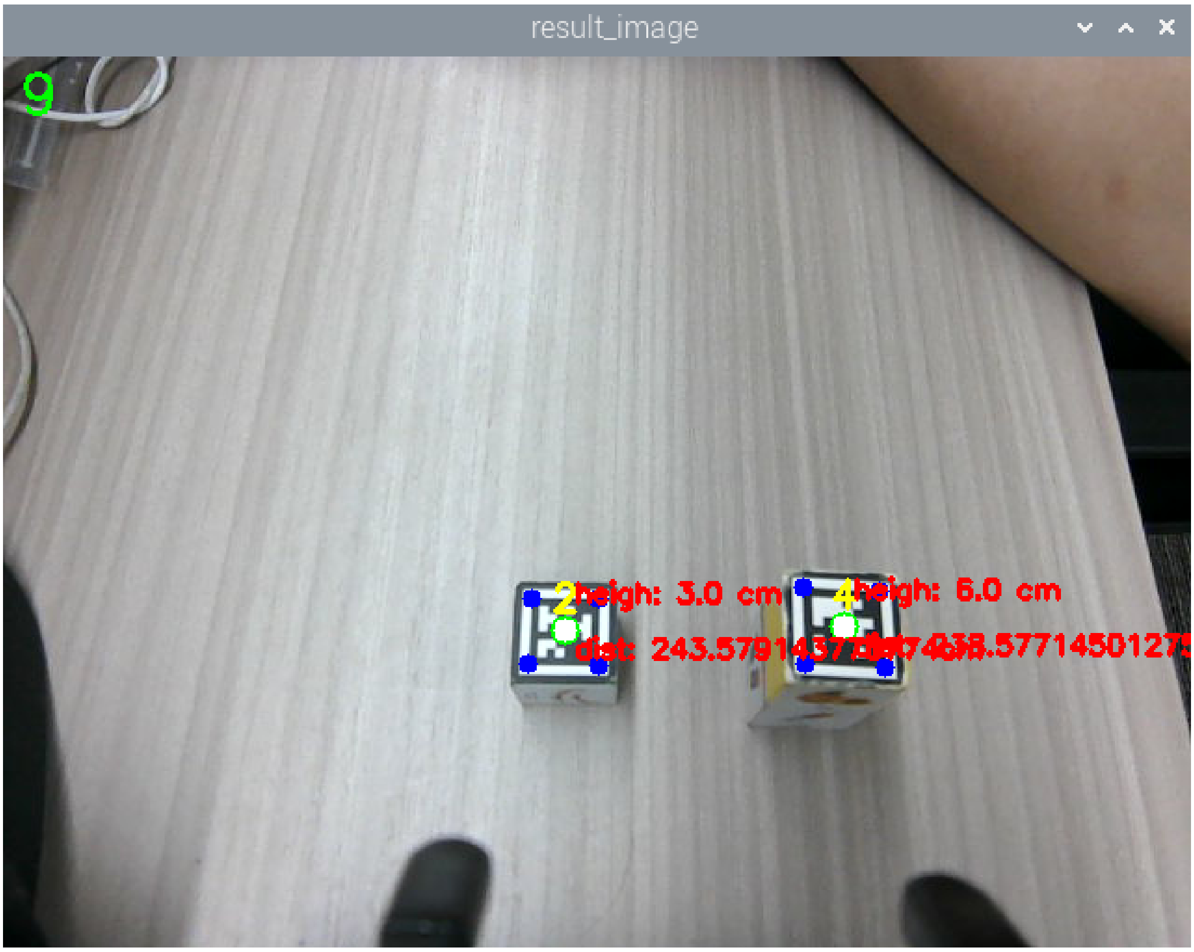
As shown,



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 height error sorting machine code program by pressing ctrl c and restart the height error sorting machine code program until the robot arm gripping program obtains the current angle information and calculates the current end position.

After the machine code ID sorting program is started, it will subscribe to the color image and depth image topics, and place the machine code block that comes with the product under the camera.

If a machine code appears in the image, the program will recognize the machine code, as shown below.



The program will print out the height of the machine code and the distance from the robot base_link. Press the spacebar, and the robot arm will lower its claw to remove the machine code with a height of 6cm. There are two cases:

- If the distance to the target machine code block is within [215, 225], the robot arm directly grabs the machine code block with its lower claw and places it at the set position according to the ID value;
- If the target machine code block is outside [215, 225], the robot will first move and adjust it to within [215, 225] based on the distance between the machine code block and the robot base coordinate system (base_link), then lower the claw to clamp it, and finally place it at the set position according to the ID value.

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/ apriltag_list.py

- Orin Motherboard

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

Import the necessary library files,

```
import cv2
import os
import numpy as np
from sensor_msgs.msg import Image
```

```
#Import the function of drawing machine code information
from M3Pro_demo.vutils import draw_tags
#Import the function to calculate the angle value of servo No. 5
from M3Pro_demo.compute_joint5 import *
#Import the library for detecting machine code
from dt_apriltags import Detector
from cv_bridge import CvBridge
import cv2 as cv
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
encoding = ['16UC1', '32FC1']
import time
import transforms3d as tfs
import tf_transformations as tf
import yaml
import math
#Import chassis PID operation related libraries
from M3Pro_demo.Robot_Move import *
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
```

Import the robot arm offset parameter file to compensate for the deviation caused by the servo virtual position.

```
offset_file = "/root/yahboomcar_ws/src/arm_kin/param/offset_value.yaml"
with open(offset_file, 'r') as file:
    offset_config = yaml.safe_load(file)
```

Program initialization and creation of publishers and subscribers,

```
def __init__(self, name):
    super().__init__(name)
    self.init_joints = [90, 120, 0, 0, 90, 90]
    self.rgb_bridge = CvBridge()
    self.depth_bridge = CvBridge()
    #Define the flag for publishing machine code information. When the value is
True, it means publishing, and when it is False, it means not publishing
    self.pubPos_flag = False
    self.pr_time = time.time()
    self.at_detector = Detector(searchpath=['apriltags'],
                                families='tag36h11',
                                nthreads=8,
                                quad_decimate=2.0,
                                quad_sigma=0.0,
                                refine_edges=1,
                                decode_sharpening=0.25,
                                debug=0)
    #Define the array that stores the current end pose coordinates
```

```
    self.CurEndPos = [0.1458589529828534, 0.00022969568906952754,
0.18566515428310748, 0.00012389155580734876, 1.0471973953319513,
8.297829493472317e-05]
    #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]])
    #Create a publisher to publish the machine code location topic. The published
message includes the x and y pixel coordinates of the center point, the depth
value corresponding to the center point, and the id value of the machine code
    self.pos_info_pub = self.create_publisher(AprilTagInfo,"PosInfo",1)
    #Create a subscriber to subscribe to the topic
    self.sub_grasp_status =
self.create_subscription(Bool,"grasp_done",self.get_graspStatusCallBack,100)
    #Create a publisher for the speed topic
    self.CmdVel_pub = self.create_publisher(Twist,"cmd_vel",1)
    #Create a publisher to control the 6 servo angle topics
    self.TargetAngle_pub = self.create_publisher(ArmJoints, "arm6_joints", 10)
    #Create a publisher for the topic of servo angle No. 5
    self.TargetJoint5_pub = self.create_publisher(Int16, "set_joint5", 10)
    #Create a subscriber to subscribe to the color image topic
    self.rgb_image_sub = Subscriber(self, Image, '/camera/color/image_raw')
    #Create a subscriber to subscribe to the depth image topic
    self.depth_image_sub = Subscriber(self, Image, '/camera/depth/image_raw')
    #Create a client that calls the robotic arm solution service
    self.client = self.create_client(ArmKinemarics, 'get_kinemarics')
    #Create a topic publisher to publish the current robot arm's 6 servo angles
    self.pub_cur_joints = self.create_publisher(CurJoints,"Curjoints",1)
    #Get the current position of the end of the robotic arm
    self.get_current_end_pos()
    self.pubSix_Arm(self.init_joints)
    self.pubCurrentJoints()
    self.ts = ApproximateTimeSynchronizer([self.rgb_image_sub,
self.depth_image_sub], 1, 0.5)
    self.ts.registerCallback(self.callback)
    #Get the compensation values in the xyz directions in the offset table
    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
    # Initialize PID parameters
    self.linearx_PID = (0.5, 0.0, 0.2)
    #Create PID control object
    self.linearx_pid = simplePID(self.linearx_PID[0] / 1000.0,
self.linearx_PID[1] / 1000.0, self.linearx_PID[2] / 1000.0)
    self.joint5 = Int16()
```

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')
    result_image = np.copy(rgb_image)
    result_image = cv.resize(result_image, (640, 480))
    #Get the deep image topic data and use CvBridge to convert the message data
into image data
    depth_image = self.depth_bridge.imgmsg_to_cv2(depth_frame, encoding[1])
    depth_to_color_image = cv2.applyColorMap(cv2.convertScaleAbs(depth_image,
alpha=1.0), cv2.COLORMAP_JET)
    frame = cv.resize(depth_image, (640, 480))
    depth_image_info = frame.astype(np.float32)
    #Call the machine code detection program, pass in the color image for
detection, and return a tags list containing information about all the detected
machine codes
    tags = self.at_detector.detect(cv2.cvtColor(rgb_image, cv2.COLOR_RGB2GRAY),
False, None, 0.025)
    #Sort the test results according to the machine code id
    tags = sorted(tags, key=lambda tag: tag.tag_id)
    #Draw the center and corner points of the machine code on the color image
    draw_tags(result_image, tags, corners_color=(0, 0, 255), center_color=(0,
255, 0))
    #Detect key input. If the key is a space, change the value of
self.pubPos_flag to True
    key = cv2.waitKey(10)
    if key == 32:
        self.pubPos_flag = True
    #If the length of the test result is not 0, it means that the machine code
has been detected
    if len(tags) > 0 :
        for i in range(len(tags)):
            #Get the center point coordinates of the current machine code
            center_x, center_y = tags[i].center
            cx = center_x
            cy = center_y
            #Calculate the depth information of the center point coordinates
            cz = depth_image_info[int(cy),int(cx)]/1000
            cv2.circle(result_image,(int(cx),int(cy)),1,(255,255,255),10)
            #Calculate the pose of the machine code in the world coordinate
system
            pose = self.compute_heigh(cx,cy,cz)
            #Calculate the height of the machine code pose[2] represents the z-
axis coordinate, the unit is centimeters
            compute_heigh = round(pose[2],2)*100
            heigh = 'heigh: ' + str(compute_heigh) + ' cm'
            dist_detect = math.sqrt(pose[1] ** 2 + pose[0]** 2)
            dist_detect = dist_detect*1000
            dist = 'dist: ' + str(dist_detect) + 'cm'
            cv.putText(result_image, heigh, (int(cx)+5, int(cy)-15),
cv.FONT_HERSHEY_SIMPLEX, 0.5, (255, 0, 0), 2)
            cv.putText(result_image, dist, (int(cx)+5, int(cy)+15),
cv.FONT_HERSHEY_SIMPLEX, 0.5, (255, 0, 0), 2)

            if self.pubPos_flag == True :
                #If the height of the current machine code is greater than 4 cm
                if  compute_heigh >4.0:
                    #print("found the target.")
                    #Judge whether the distance is within the range of [215,
225]. If not, move the chassis to adjust the distance. If yes, issue a stop
command.
```

```
                    if abs(dist_detect - 220.0)>5 and self.adjust_dist==True:
                        self.move_dist(dist_detect)
                    else:
                        self.pubVel(0,0,0)
                        #Create a machine code information location message
object and assign it
                        tag = AprilTagInfo()
                        center_x, center_y = tags[i].center
                        tag.id = tags[i].tag_id
                        tag.x = center_x
                        tag.y = center_y
                        tag.z = depth_image_info[int(tag.y),int(tag.x)]/1000
                        #Calculate the offset angle of the machine code block
based on the corner coordinates
                        vx = int(tags[i].corners[0][0]) - int(tags[i].corners[1]
[0])
                        vy = int(tags[i].corners[0][1]) - int(tags[i].corners[1]
[1])
                        target_joint5 = compute_joint5(vx,vy)
                        print("target_joint5: ",target_joint5)
                        self.joint5.data = int(target_joint5)
                        #Judge whether the depth information of the center point
is valid. If it is not 0, it means it is valid
                        if tag.z!=0:
                            #Publish the topic message of the angle value of the
No. 5 servo
                            self.TargetJoint5_pub.publish(self.joint5)
                            #Publish machine code location information topic
message
                            self.pos_info_pub.publish(tag)
                            self.pubPos_flag = False
                        else:
                            print("Invalid distance.")
    else:
        self.pubVel(0,0,0)
    result_image = cv2.cvtColor(result_image, cv2.COLOR_RGB2BGR)
    cur_time = time.time()
    fps = str(int(1/(cur_time - self.pr_time)))
    self.pr_time = cur_time
    cv2.putText(result_image, fps, (10, 30), cv2.FONT_HERSHEY_SIMPLEX, 1, (0,
255, 0), 2)
    cv2.imshow("result_image", result_image)
    key = cv2.waitKey(1)
```