4.AR vision

Orin motherboard users can directly run the program by opening the terminal and entering the tutorial command. Jetson-Nano motherboard users need to first enter a Docker container and then enter the tutorial command in the Docker container to start the program.

4.1 Overview

Augmented Reality, referred to as "AR",technology is a technology that cleverly integrates virtual information with the real world. It widely uses a variety of technical means such as multimedia, three-dimensional modeling, real-time tracking and registration, intelligent interaction, and sensing.After simulating computer-generated text, images, three-dimensional models, music, videos and other virtual information, it is applied to the real world. The two types of information complement each other, thereby achieving "enhancement" of the real world.

The AR system has three outstanding characteristics: ① information integration between the real world and the virtual world; ② real-time interactivity; ③ adding positioning virtual objects in the three-dimensional scale space.

Augmented reality technology includes new technologies and methods such as multimedia, three-dimensional modeling, real-time video display and control, multi-sensor fusion, real-time tracking and registration, and scene fusion.

4.2 How to use

When using the AR case, you must have the internal parameters of the camera, otherwise it will not run (the factory image has completed the calibration of the internal parameters of the camera). The internal parameter files are in the same directory as the code.

4.2.1 Camera internal parameter calibration

Start monocular camera

```
ros2 launch orbbec_camera dabai_dcw2.launch.py
```

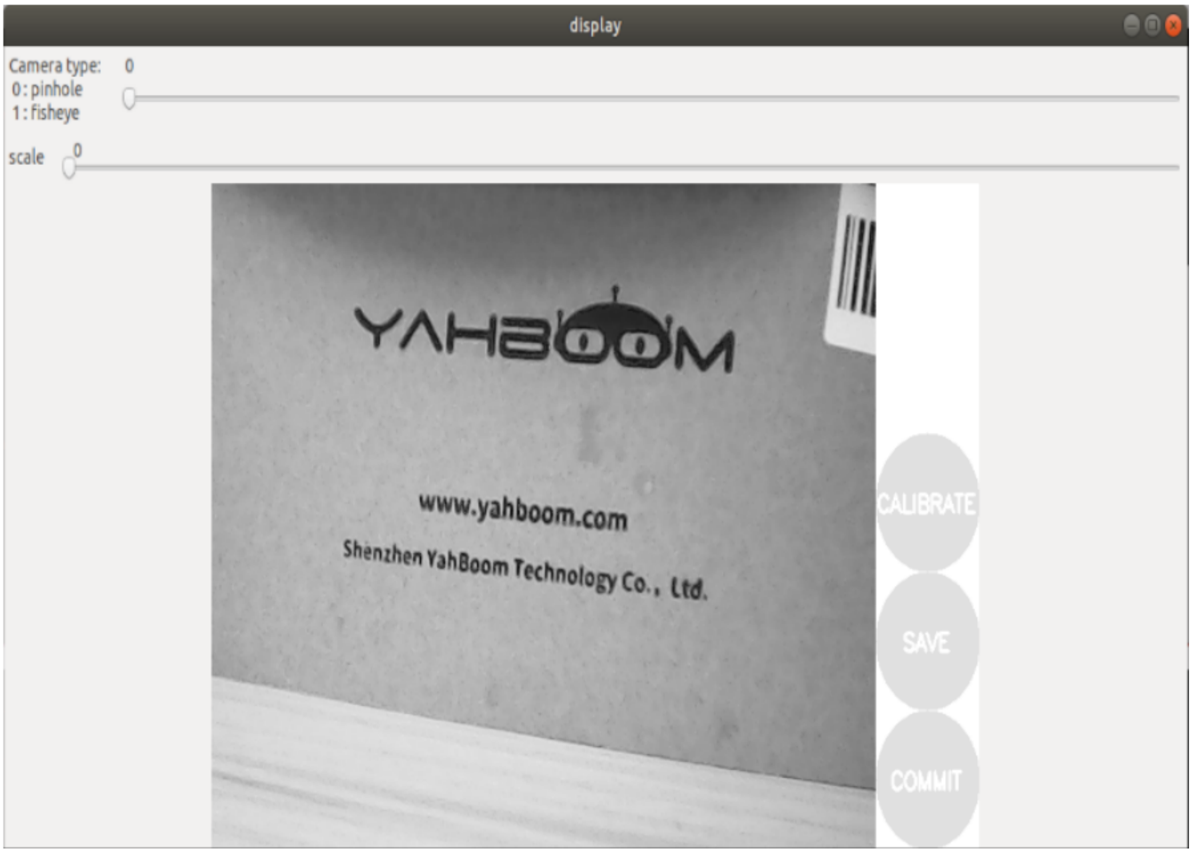
Start calibration node

```
ros2 run camera_calibration cameracalibrator --size 9x6 --square 0.02 --ros-args
--remap /image:=/camera/color/image_raw
```

size： Calibrate the number of internal corner points of the checkerboard, for example, 9X6, with a total of six rows and nine columns of corner points.

square: The side length of the checkerboard, in meters.

image: Image topic posted by the camera



Calibration screen

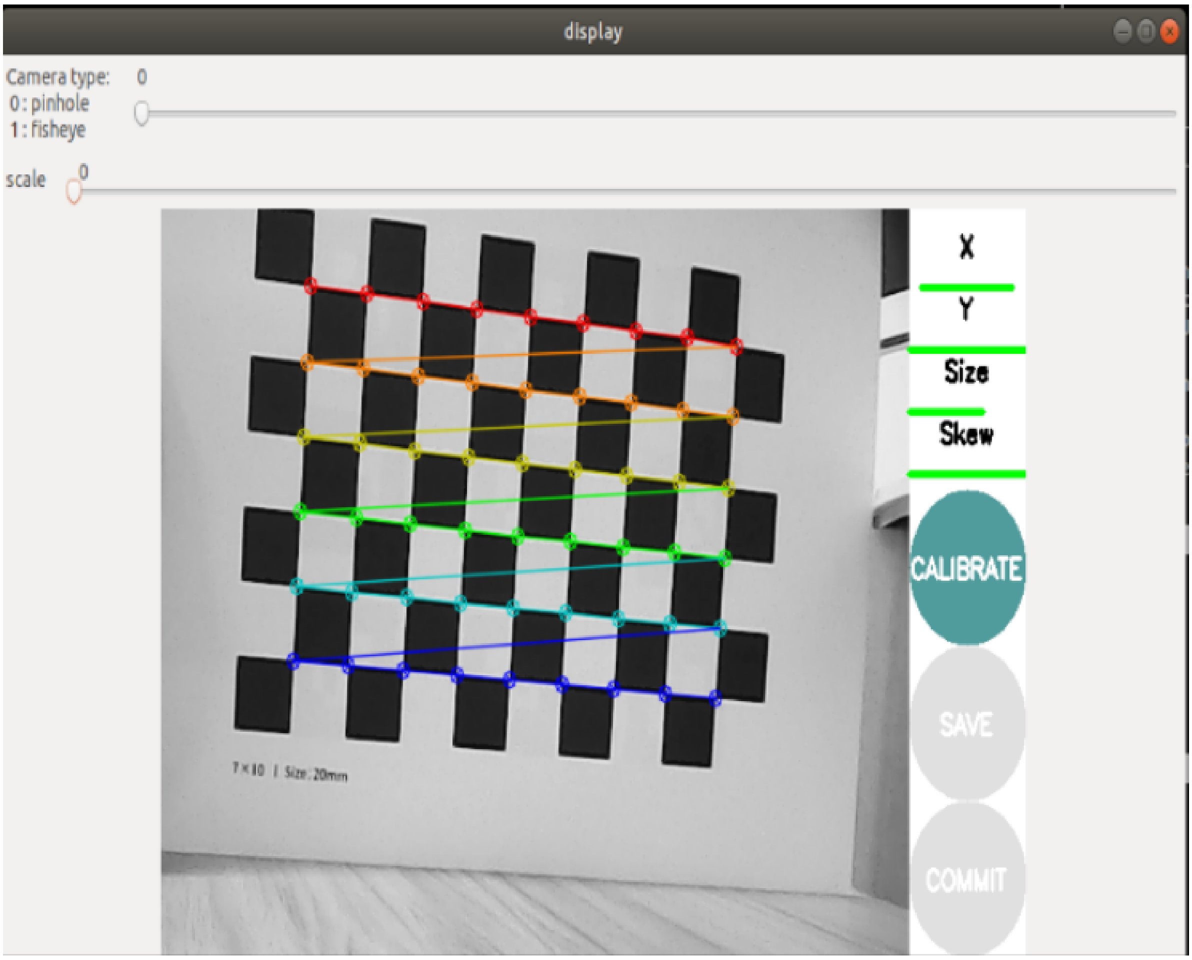
X: The left and right movement of the checkerboard in the camera field of view

Y: The checkerboard moves up and down in the camera field of view

Size: the movement of the checkerboard back and forth in the camera field of view

Skew: The tilt and rotation of the checkerboard in the camera's field of view

After successful startup, place the checkerboard in the center of the screen and change to different positions. The system will identify it independently. The best situation is that the lines under [X], [Y], [Size], and [Skew] will first change from red to yellow and then to green as the data is collected, filling them as fully as possible.



- Click [CALIBRATE] to calculate the internal parameters of the camera. The more pictures you have, the longer it will take. Just wait. (Sixty or seventy is enough, too many can easily get stuck).
- Click [SAVE] to save the calibration results to [/tmp/calibrationdata.tar.gz] of the currently running terminal.

After the calibration is completed, you can move out the [/tmp/calibrationdata.tar.gz] file to see the content.

```
sudo mv /tmp/calibrationdata.tar.gz ~
```

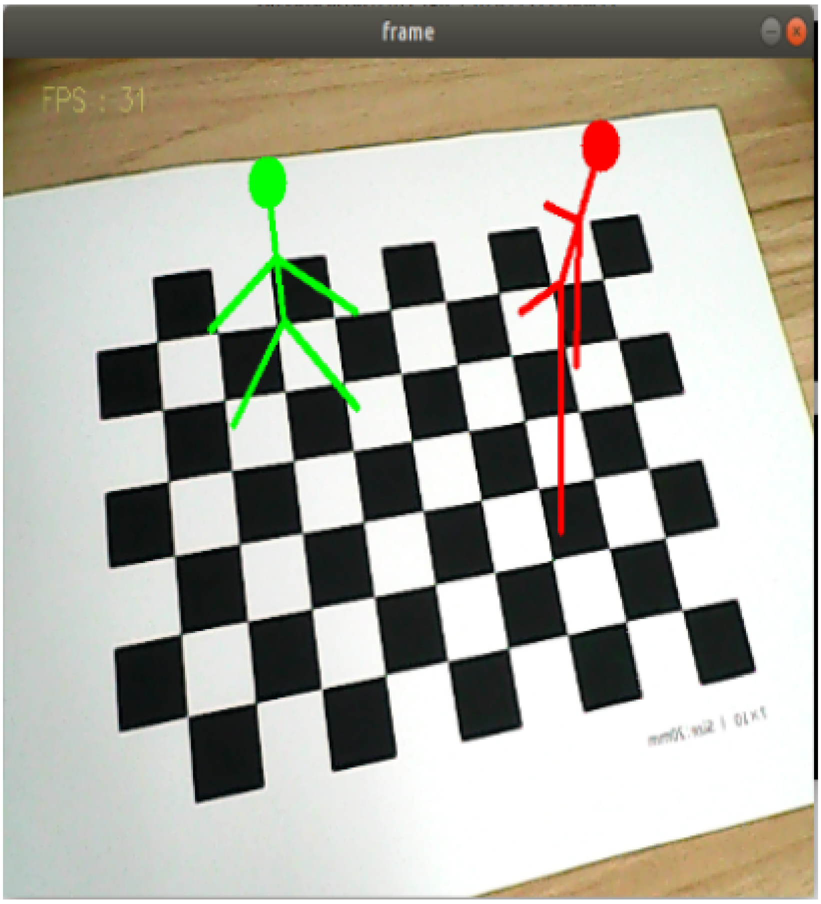
After decompression, you'll find the calibrated images, an ost.txt file, and an ost.yaml file. ost.yaml contains the camera's intrinsic parameters. Copy the contents of this intrinsic parameter file and overwrite the existing ost.yaml file located at ~/dofbot_ws/src/dofbot_visual/AR.

Note: The factory image has been calibrated with parameters, and can be used directly by starting the program. If the camera screen is started, please close the camera process first and then start the program. 。

4.2.2 Start up

Terminal input,

```
ros2 run dofbot_pro_vision simple_ar
```



After the program starts, place the checkerboard in front of the camera. Note that you need to see the entire checkerboard, otherwise the program will exit. After the entire checkerboard is recognized, the following 12 effects will be displayed:

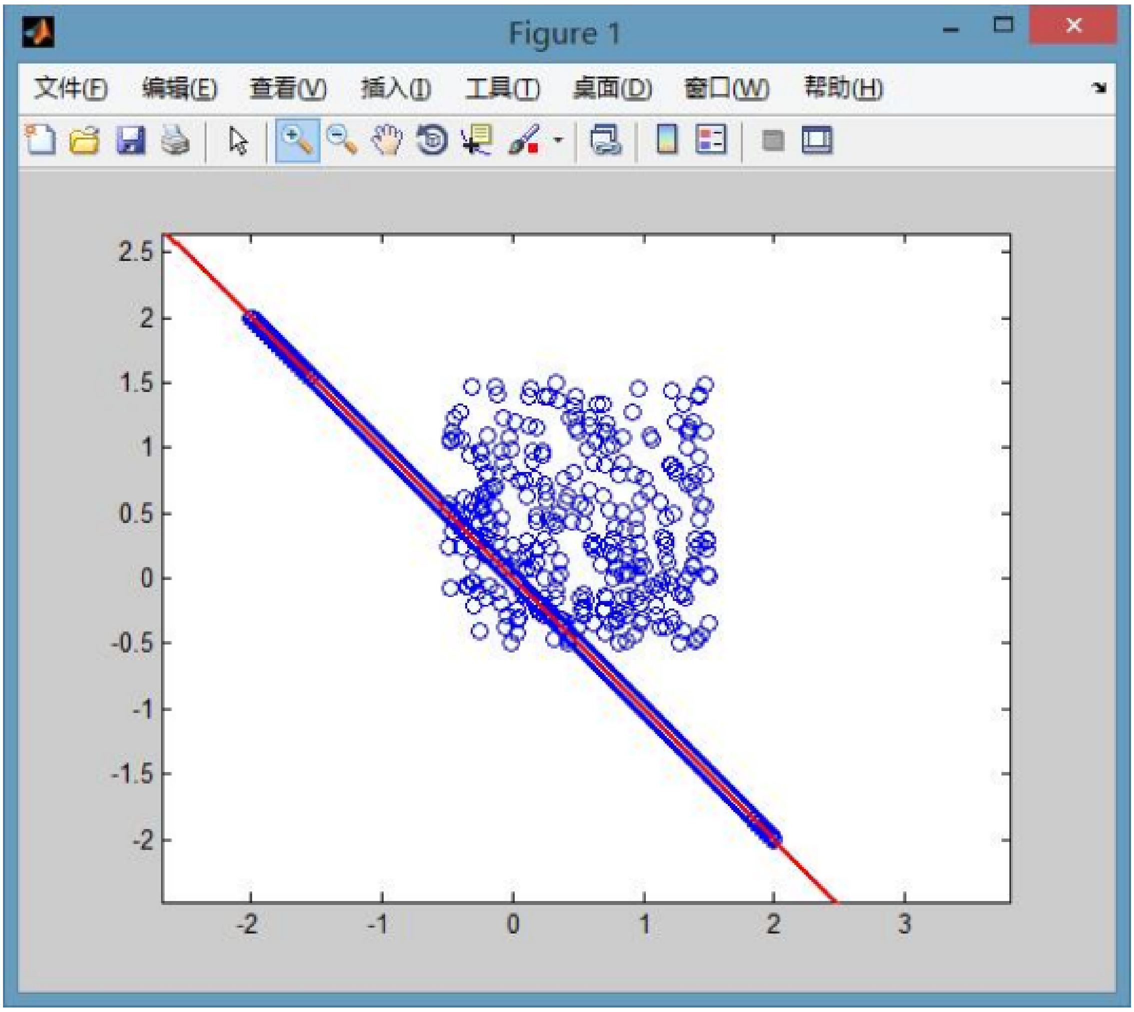
```
["Triangle", "Rectangle", "Parallelogram","WindMill","TableTennisTable",
"Ball","Arrow", "Knife", "Desk","Bench", "Stickman", "ParallelBars"]
```

Click on the image and press F to switch the displayed effect.

4.3.1、RANSAC方案

- Algorithm principle: Use RANSAC scheme to find object pose from 3D-2D point correspondence

  The RanSaC algorithm (Random Sampling Consistent) was originally a classic algorithm used for data processing. Its function is to extract specific components in objects in the presence of a large amount of noise. The figure below is an illustration of the effect of the RanSaC algorithm. There are some points in the picture that obviously satisfy a certain straight line, and there are other points that are pure noise. The purpose is to find the equation of the straight line in the presence of a large amount of noise, when the amount of noise data is 3 times that of the straight line.




```
    If the least squares method is used, such an effect cannot be obtained, and
the straight line will be slightly higher than the straight line in the picture.
```

- The basic assumptions of RANSAC are：
    - The data consists of "internal points", for example: the distribution of the data can be explained by some model parameters;
    - "Outliers" are data that cannot fit the model;
    - Data other than this is noise.
- The causes of outliers include: extreme values of noise; wrong measurement methods; wrong assumptions about data. RANSAC also makes the following assumption: given a set of (usually small) internal points, there is a process that can estimate the parameters of the model; and the model can explain or be applicable to the internal points.

4.3.2 Source code

Source code location：

```
#Jetson-Nano users need to enter the Docker container to view this.
~/dofbot_pro_ws/src/dofbot_pro_vision/dofbot_pro_vision/simple_ar.py
```

```
#common lib
import os
import sys
import time
import cv2 as cv
import numpy as np
```

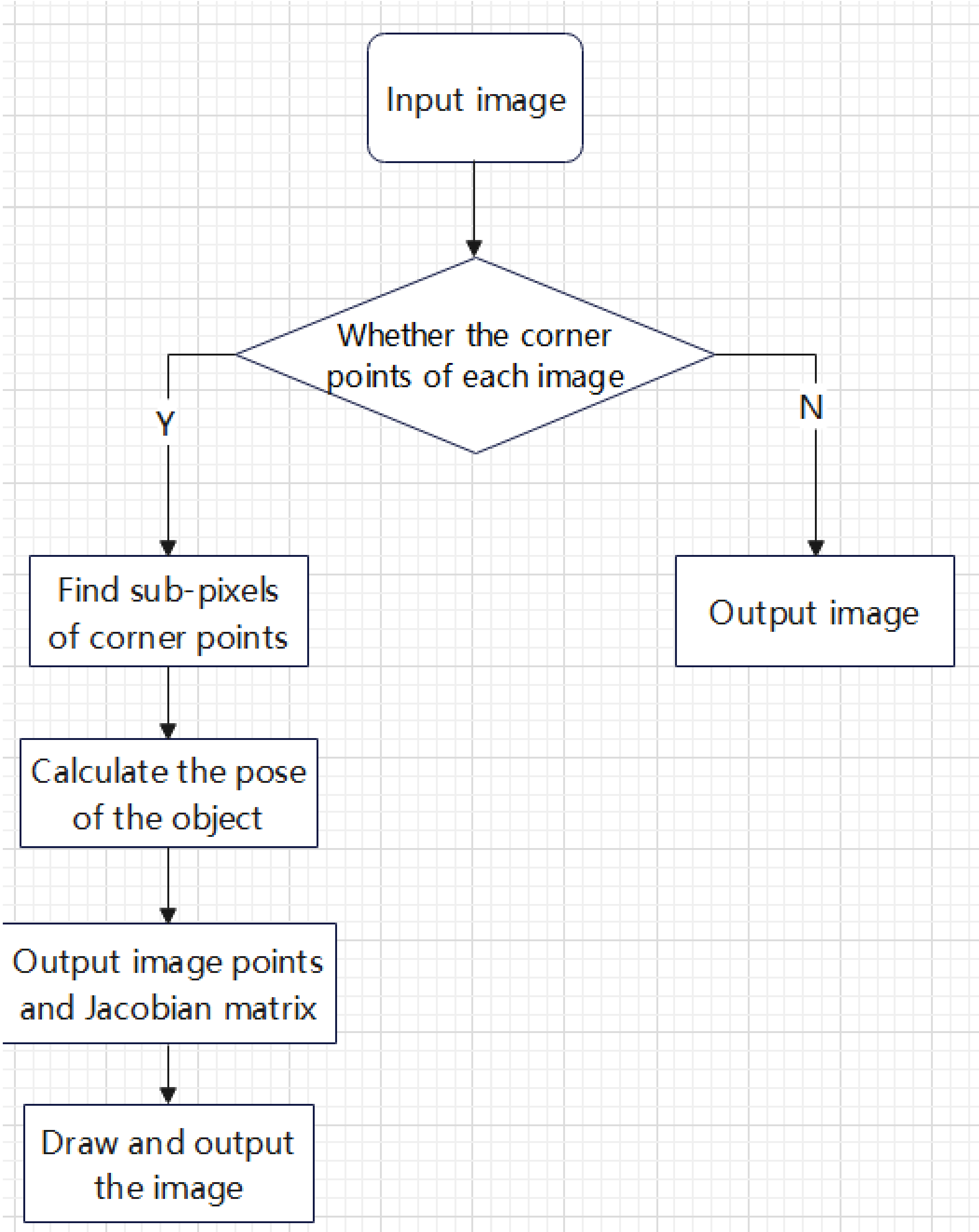
```python
from cv_bridge import CvBridge

#ros2 lib
import rclpy
from rclpy.node import Node
from std_msgs.msg import String
from sensor_msgs.msg import CompressedImage,Image

print("import done")

cv_edition = cv.__version__
print("cv_edition: ",cv_edition)

class simple_AR(Node):
    def __init__(self,name):
        super().__init__(name)
        #create pub
        self.pub_img = self.create_publisher(Image,'/simpleAR/camera',1)
        #create sub
        self.sub_graphics =
self.create_subscription(String,'/Graphics_topic',self.choose_Graphics,1)

        self.flip = True
        self.index = 0
        self.graphics = ["Triangle", "Rectangle", "Parallelogram","WindMill",
                         "TableTennisTable", "Ball", "Arrow", "Knife", "Desk",
                         "Bench", "Stickman", "ParallelBars"]
        self.Graphics = self.graphics[self.index]
        self.axis = np.float32([
            [0, 0, -1], [0, 8, -1], [5, 8, -1], [5, 0, -1],
            [1, 2, -1], [1, 6, -1], [4, 2, -1], [4, 6, -1],
            [1, 0, -4], [1, 8, -4], [4, 0, -4], [4, 8, -4],
            [1, 2, -4], [1, 6, -4], [4, 2, -4], [4, 6, -4],
            [0, 1, -4], [3, 2, -1], [2, 2, -3], [3, 2, -3],
            [1, 2, -3], [2, 2, -4], [2, 2, -5], [0, 4, -4],
            [2, 3, -4], [1, 3, -4], [4, 3, -5], [4, 5, -5],
            [1, 2, -3], [1, 6, -3], [5, 2, -3], [5, 6, -3],
            [3, 4, -5], [0, 6, -4], [5, 6, -4], [2, 8, -4],
            [3, 8, -4], [2, 6, -4], [2, 0, -4], [1, 5, -4],
            [3, 0, -4], [3, 2, -4], [0, 3, -4], [1, 2, -4],
            [4, 2, -4], [5, 3, -4], [2, 7, -4], [3, 7, -4],
            [3, 3, -1], [3, 5, -1], [1, 5, -1], [1, 3, -1],
            [3, 3, -3], [3, 5, -3], [1, 5, -3], [1, 3, -3],
            [1, 3, -6], [1, 5, -6], [3, 3, -4], [3, 5, -4],
            [0, 0, -4], [3, 1, -4], [1, 1, -4], [0, 2, -4],
            [2, 4, -4], [4, 4, -4], [0, 8, -4], [5, 8, -4],
            [5, 0, -4], [0, 4, -5], [5, 4, -4], [5, 4, -5],
            [2, 5, -1], [2, 7, -1], [2, 6, -3], [2, 6, -5],
            [2, 5, -3], [2, 7, -3]
            ])
        self.frame = None
        self.img_name = 'img'
        self.patternSize = (6, 9)
        self.bridge = CvBridge()
        yaml_path =
'/home/jetson/dofbot_pro_ws/src/dofbot_pro_vision/config/camera.yaml'
        #yaml_path =
'/root/dofbot_pro_ws/src/dofbot_pro_vision/config/camera.yaml'
```

```
        if os.path.exists(yaml_path):
            fs = cv.FileStorage(yaml_path, cv.FileStorage_READ)
            self.cameraMatrix = fs.getNode("camera_matrix").mat()
            self.distCoeffs = fs.getNode("distortion_coefficients").mat()
        else:
            self.distCoeffs, self.cameraMatrix = (), ()
        self.objectPoints = np.zeros((6 * 9, 3), np.float32)
        self.objectPoints[:, :2] = np.mgrid[0:6, 0:9].T.reshape(-1, 2)
        self.capture = cv.VideoCapture(0)
        if cv_edition[0]=='3': self.capture.set(cv.CAP_PROP_FOURCC,
cv.VideoWriter_fourcc(*'XVID'))
        else: self.capture.set(cv.CAP_PROP_FOURCC, cv.VideoWriter.fourcc('M',
'J', 'P', 'G'))
        self.capture.set(6, cv.VideoWriter_fourcc('M', 'J', 'P', 'G'))
        self.capture.set(cv.CAP_PROP_FRAME_WIDTH, 640)
        self.capture.set(cv.CAP_PROP_FRAME_HEIGHT, 480)
        self.timer = self.create_timer(0.001, self.on_timer)


    def choose_Graphics(self,msg):
        if not isinstance(msg, String): return
        if msg.data in self.graphics: self.Graphics = msg.data
        else: self.graphics_update()

    def graphics_update(self):
        self.index += 1
        if self.index >= len(self.graphics): self.index = 0
        self.Graphics = self.graphics[self.index]

    def on_timer(self):
        ret, frame = self.capture.read()
        action = cv.waitKey(10) & 0xFF
        frame =self.process(frame, action)
        cv.imshow('frame', frame)
        #if len(binary) != 0: cv.imshow('frame', ManyImgs(1, ([frame, binary])))
        #else:cv.imshow('frame', frame)
        if action == ord('q') or action == 113:
            self.capture.release()
            cv.destroyAllWindows()

    def process(self, img, action):
        if self.flip == True: img = cv.flip(img, 1)
        if action == ord('f') or action == ord('F'): self.graphics_update()
        gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)

        # Find the corner of each image
        retval, corners = cv.findChessboardCorners(
            gray, self.patternSize, None,
            flags=cv.CALIB_CB_ADAPTIVE_THRESH + cv.CALIB_CB_NORMALIZE_IMAGE +
cv.CALIB_CB_FAST_CHECK)

        # Find corner subpixels
        if retval:
            corners = cv.cornerSubPix(
                gray, corners, (11, 11), (-1, -1),
                (cv.TERM_CRITERIA_EPS + cv.TERM_CRITERIA_MAX_ITER, 30, 0.001))

            # Compute object pose solvePnPRansac
```

```
            retval, rvec, tvec, inliers = cv.solvePnPRansac(
                self.objectPoints, corners, self.cameraMatrix, self.distCoeffs)

            # Output image points and Jacobian matrix
            image_Points, jacobian = cv.projectPoints(
                self.axis, rvec, tvec, self.cameraMatrix, self.distCoeffs, )
            img = self.draw(img, corners, image_Points)
        cv.putText(img, self.Graphics, (240, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9,
(0, 0, 255), 1)
        self.pub_img.publish(self.bridge.cv2_to_imgmsg(img, "bgr8"))
        return img

    def draw(self, img, corners, image_Points):

        # drawContours the color order of the drawing is BGR
        img_pts = np.int32(image_Points).reshape(-1, 2)
        if self.Graphics == "Triangle":
            cv.drawContours(img, [np.array([img_pts[14], img_pts[15],
img_pts[23]])], -1, (255, 0, 0), -1)
        elif self.Graphics == "Rectangle":
            cv.drawContours(img, [np.array([img_pts[12], img_pts[13],
img_pts[15], img_pts[14]])], -1, (0, 255, 0), -1)
        elif self.Graphics == "Parallelogram":
            cv.drawContours(img, [np.array([img_pts[12], img_pts[10],
img_pts[15], img_pts[9]])], -1, (65, 105, 225), 1)
        elif self.Graphics == "WindMill":
            cv.drawContours(img, [np.array([img_pts[60], img_pts[38],
img_pts[61], img_pts[21]])], -1, (0, 0, 255), -1)
            cv.drawContours(img, [np.array([img_pts[10], img_pts[14],
img_pts[58], img_pts[21]])], -1, (0, 0, 255), -1)
            cv.drawContours(img, [np.array([img_pts[62], img_pts[63],
img_pts[23], img_pts[21]])], -1, (0, 0, 255), -1)
            cv.drawContours(img, [np.array([img_pts[25], img_pts[64],
img_pts[65], img_pts[21]])], -1, (0, 0, 255), -1)
            cv.line(img, tuple(img_pts[64]), tuple(img_pts[35]), (0, 255, 0), 3)
        elif self.Graphics == "TableTennisTable":
            cv.line(img, tuple(img_pts[0]), tuple(img_pts[60]), (255, 0, 0), 3)
            for i in range(1, 4):
                cv.line(img, tuple(img_pts[i]), tuple(img_pts[65 + i]), (255, 0,
0), 3)
            cv.drawContours(img, [np.array([img_pts[60], img_pts[66],
img_pts[67], img_pts[68]])], -1, (0, 255, 0), -1)
            cv.drawContours(img, [np.array([img_pts[23], img_pts[69],
img_pts[71], img_pts[70]])], -1, (0, 0, 255), -1)
        elif self.Graphics == "Ball": cv.circle(img, tuple(img_pts[22]), 30, (0,
0, 255), -1)
        elif self.Graphics == "Arrow":
            cv.drawContours(img, [np.array([img_pts[13], img_pts[34],
img_pts[36]])], -1, (0, 255, 0), -1)
            cv.drawContours(img, [np.array([img_pts[37], img_pts[15],
img_pts[10], img_pts[38]])], -1, (0, 255, 0), -1)
        elif self.Graphics == "Knife":
            cv.drawContours(img, [np.array([img_pts[58], img_pts[24],
img_pts[35], img_pts[47]])], -1, (160, 252, 0),
                            -1)
            cv.drawContours(img, [np.array([img_pts[40], img_pts[38],
img_pts[21], img_pts[41]])], -1, (30, 144, 255),
                            -1)
```

```
            cv.drawContours(img, [np.array([img_pts[42:46]])], -1, (0, 0, 255),
-1)
        elif self.Graphics == "Desk":
            for i in range(4):
                cv.line(img, tuple(img_pts[4 + i]), tuple(img_pts[12 + i]),
(163, 148, 128), 3)
            cv.drawContours(img, [np.array([img_pts[14], img_pts[12],
img_pts[13], img_pts[15]])], -1, (0, 199, 140),
                            -1)
        elif self.Graphics == "Bench":
            for i in range(4):
                cv.line(img, tuple(img_pts[48 + i]), tuple(img_pts[52 + i]),
(255, 0, 0), 3)
            cv.drawContours(img, [img_pts[52:56]], -1, (0, 0, 255), -1)
            cv.drawContours(img, [img_pts[54:58]], -1, (139, 69, 19), -1)
        elif self.Graphics == "Stickman":
            cv.line(img, tuple(img_pts[18]), tuple(img_pts[4]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[18]), tuple(img_pts[6]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[18]), tuple(img_pts[21]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[21]), tuple(img_pts[19]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[21]), tuple(img_pts[20]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[21]), tuple(img_pts[22]), (0, 0, 255), 3)
            cv.circle(img, tuple(img_pts[22]), 15, (0, 0, 255), -1)
            cv.line(img, tuple(img_pts[74]), tuple(img_pts[72]), (0, 255, 0), 3)
            cv.line(img, tuple(img_pts[74]), tuple(img_pts[73]), (0, 255, 0), 3)
            cv.line(img, tuple(img_pts[74]), tuple(img_pts[37]), (0, 255, 0), 3)
            cv.line(img, tuple(img_pts[37]), tuple(img_pts[76]), (0, 255, 0), 3)
            cv.line(img, tuple(img_pts[37]), tuple(img_pts[77]), (0, 255, 0), 3)
            cv.line(img, tuple(img_pts[37]), tuple(img_pts[75]), (0, 255, 0), 3)
            cv.circle(img, tuple(img_pts[75]), 15, (0, 255, 0), -1)
        elif self.Graphics == "ParallelBars":
            for i in range(4):
                cv.line(img, tuple(img_pts[4 + i]), tuple(img_pts[12 + i]),
(255, 0, 0), 3)
            cv.line(img, tuple(img_pts[8]), tuple(img_pts[9]), (0, 0, 255), 3)
            cv.line(img, tuple(img_pts[10]), tuple(img_pts[11]), (0, 0, 255), 3)
        return img

def main():
    print("start")
    rclpy.init()
    ar = simple_AR('simple_AR')
    rclpy.spin(ar)
```

程序流程图，


Input image
Whether the corner points of each image
Y
N
Find sub-pixels of corner points
Output image
Calculate the pose of the object
Output image points and Jacobian matrix
Draw and output the image