# QR code follow


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## 1. Program Functionality

> After the program starts, it automatically detects the QR code on the screen, and the robot enters follow mode. The servos and gimbal will lock onto the center of the QR code and maintain it in the center of the screen. Press the `q/Q key` to exit the program. The remote controller's `R2` function provides a [Pause/Start] function for this gameplay.

⚠ This function will only begin following the QR code after the characters are successfully decoded. Therefore, the recognition rate and following performance will be lower than other visual examples!

📝 The following object example uses a QR code printed on A5-sized paper. If you change the following object, you will need to adjust the corresponding parameters to achieve your desired effect!

## 2. Program Code Reference Path

```
~/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_astra/yahboomcar_astra/qrFollow.py
~/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_astra/yahboomcar_astra/common/astra_common.py
```

- qrFollow.py

  Mainly performs QR code recognition. Based on the center coordinates of the QR code, it calculates the required servo rotation angle and the required angular velocity of the car. It also calculates the required linear velocity of the car based on the area of the QR code. After PID calculation, the data is published to the car chassis.

- astra_common.py
  - QR Code Detection (detect_qrcode()): Identifies and locates QR codes, supports geometric verification, and decodes and displays text.
  - Shape Detection (is_regular_square function): Verifies whether the detected QR code is a regular square.

# 3. Program Startup

## 3.1. Startup Command

**For the Raspberry Pi PI5 controller, you must first enter the Docker container. This is not necessary for the Orin board.**

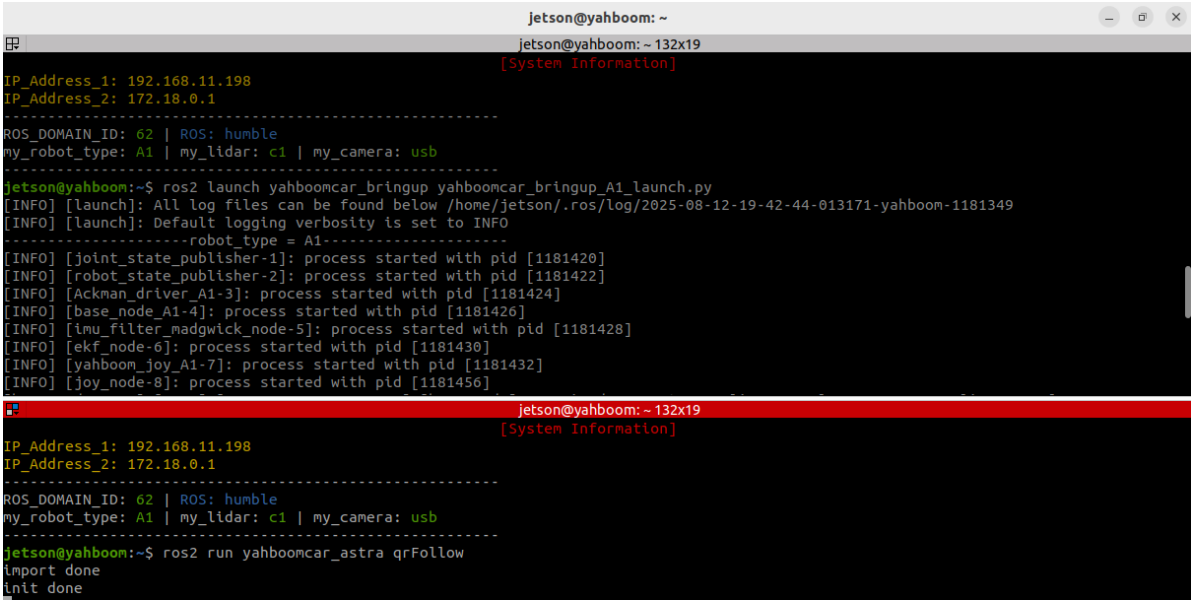
**Enter the Docker container (for steps, see the Docker section [3. Docker Submission and Multi-Terminal Access]).**

Enter the terminal.

```
# Start the car chassis and joystick nodes.

ros2 launch yahboomcar_bringup yahboomcar_bringup_A1_launch.py
# Start the QR code tracking program.

ros2 run yahboomcar_astra qrFollow
```




After the program starts, the camera screen will appear and the QR code will be detected in real time.

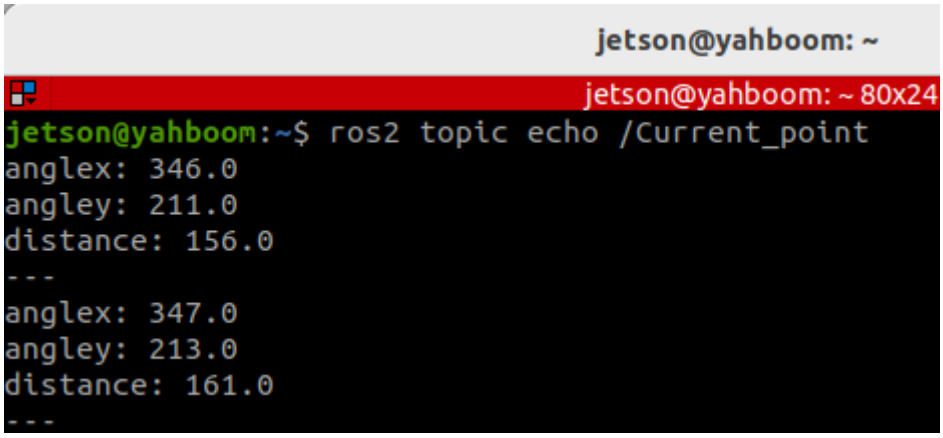
When a QR code is detected, a green rectangle will be drawn around it if it is successfully decoded, and a red rectangle will be drawn if it fails. The decode information, the center coordinates of the QR code, and the area size will also be displayed.

frame
FPS : 24
x:302 y:224 area:395
Yahboom
(x=282, y=161) ~ R:209 G:215 B:202

Then, the robot enters tracking mode. Slowly move the QR code, and the robot and servo gimbal will follow.

In addition, we can also enter the following command to print information about the target center coordinates and area size:

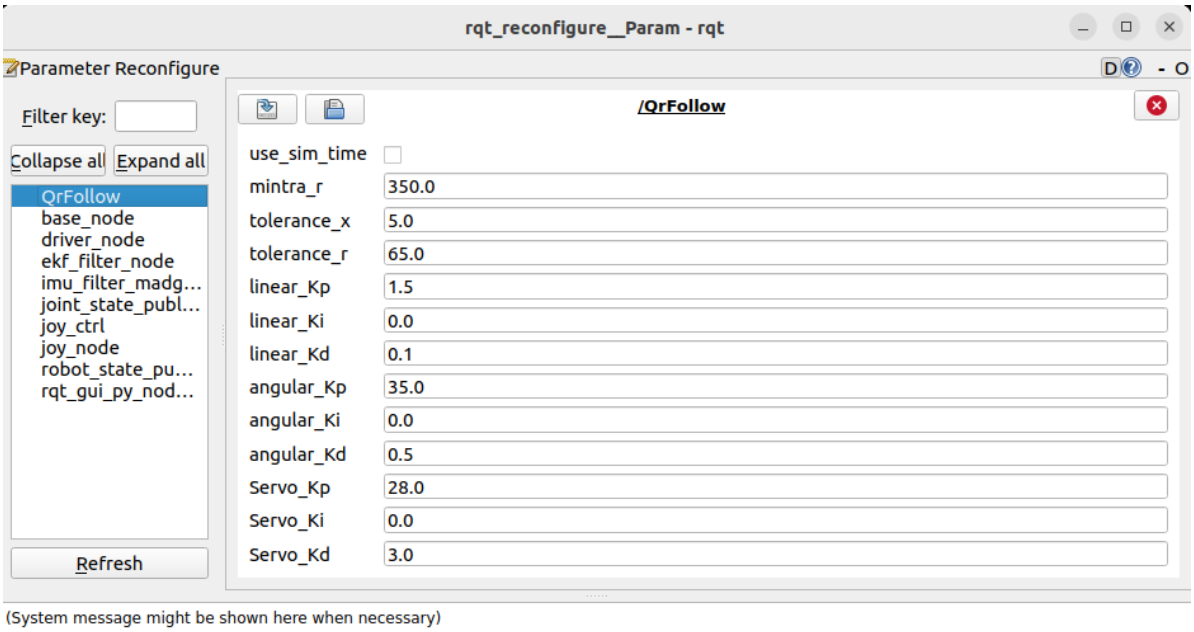
```
ros2 topic echo /Current_point
```



## 3.2 Dynamic Parameter Adjustment

Enter in the terminal:

```
ros2 run rqt_reconfigure rqt_reconfigure
```




☑ After modifying the parameters, click a blank area in the GUI to enter the parameter value. Note that this will only take effect for the current boot. To permanently take effect, you need to modify the parameters in the source code.

As shown in the figure above:

- qrFollow is primarily responsible for robot motion. PID-related parameters can be adjusted to optimize robot motion.

🛠 Parameter Analysis:

[mintra_r]: Critical tracking area. When the QR code area is smaller than this value, the robot moves forward; when it is larger than this value, the robot moves backward.

[tolerance_x], [tolerance_r]: X-axis position tolerance. When the deviation between the QR code center's x-coordinate and the screen center (`320`) is smaller than this value, alignment is considered complete. Area tolerance: When the deviation between the detected QR code area and the critical tracking area (`mintra_r`) is smaller than this value, the distance is considered appropriate.

[linear_Kp], [linear_Ki], [linear_Kd]: PID control of linear velocity during robot following.

[angular_Kp], [angular_Ki], [angular_Kd]: PID control of angular velocity during robot following.

[Servo_Kp], [Servo_Ki], [Servo_Kd]: PID control of the servo gimbal speed during the following process.

# 4. Core Code

## 4.1. qrFollow.py

This program has the following main functions:

- Opens the camera and acquires an image;
- Calls the detect_qrcode function to recognize a QR code;
- Calculates the center coordinates and area size of the QR code;
- Uses the PID algorithm to calculate the control variable;
- Issues control commands to the robot and servo.

The following is some of the core code:

```
# Define the servo data publisher
self.pub_Servo = self.create_publisher(ServoControl, 'Servo', 10)
# Define the vehicle velocity publisher
self.pub_cmdVel = self.create_publisher(Twist, '/cmd_vel', 10)
# Create a publisher to publish the center coordinates and area of ••the tracked
object
self.pub_position = self.create_publisher(Position, "/Current_point", 10)
# Define the controller node data subscriber
self.sub_JoyState = self.create_subscription(Bool,"/JoyState",
self.JoyStateCallback, 1)
...
# QR code recognition and processing
processed_frame, (x, y, w, h) = detect_qrcode(frame)
if processed_frame is not None:
    self.Center_x = x + w // 2
    self.Center_y = y + h // 2
    self.Center_r = w * h // 100
    # Issue control instructions
    self.execute(self.Center_x, self.Center_y, self.Center_r)
...

# According to the x value, y value and area size, use the PID algorithm to
calculate the car speed and servo angle
def execute(self, x, y, z=None):
    position = Position()
    position.anglex = x * 1.0
    position.angley = y * 1.0
    position.distance = z * 1.0
    self.pub_position.publish(position)
    ...
    # PID control calculation
    [linear_Pid, Servox_Pid, Servoy_Pid] = self.PID_controller.update([
        z - self.mintra_r,  # Distance error
        x - 320,            # X-axis error
        y - 240             # Y-axis error
    ])
    angular_Pid = self.angular_PID_controller.update([
        self.PWMServo_X - self.init_servos1  # Servo angle error
    ])
    ...
    # Limit output range
    linear_Pid = max(-0.55, min(linear_Pid, 0.28))
    angular_Pid = max(-3.0, min(angular_Pid, 3.0))
```

```
    ...
    # Limit the servo PID polarity and maximum value
    Servox_Pid = Servox_Pid * (abs(Servox_Pid) <=self.Servo_Kp/5.6)
    Servoy_Pid = Servoy_Pid * (abs(Servoy_Pid) <=self.Servo_Kp/5.6)
    ...
    # Issue control instructions
    self.pub_Servo.publish(self.servo_angle)
    self.pub_cmdVel.publish(self.twist)
```

## 4.2、astra_common.py

```
def detect_qrcode(image):
    qr_decoder = cv.QRCodeDetector()
    decoded_text, points, _ = qr_decoder.detectAndDecode(image)
    if points is not None:
        # Calculate center point and bounding box
        center_x = int(np.mean(points[:, 0]))
        center_y = int(np.mean(points[:, 1]))
        x, y, w, h = cv.boundingRect(points)
        return image, (x, y, w, h)
    return None, (0, 0, 0, 0)
...
def is_regular_square(points):
    # Calculate the lengths of the four sides
    edges = [np.linalg.norm(points[(i + 1) % 4] - points[i]) for i in range(4)]
    # Check if the angle is close to 90 degrees
    angles = []
    for i in range(4):
        vec1 = points[(i - 1) % 4] - points[i]
        vec2 = points[(i + 1) % 4] - points[i]
        angle_rad = np.arccos(np.dot(vec1, vec2) / (np.linalg.norm(vec1) *
np.linalg.norm(vec2)))
        angles.append(np.degrees(angle_rad))
    return max(abs(angle - 90) for angle in angles) < 30
```