Angular Velocity Calibration

This lesson uses the Raspberry Pi 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 lesson in the terminal. For instructions on entering the Docker container from the host computer, refer to **[01. Robot Configuration and Operation Guide] -- [4.Enter Docker (For JETSON Nano and RPi 5)]**. For RDKX5 and Orin boards, simply open a terminal and enter the commands mentioned in this lesson.

1. Program Description

Run the program and adjust the parameters using the dynamic parameter adjuster to calibrate the angular velocity of the car. To visually demonstrate the angular velocity calibration, give the command to move the car forward 1 meter and observe how far it actually travels and whether it falls within the error range.

2. Program Startup

2.1 Startup Command

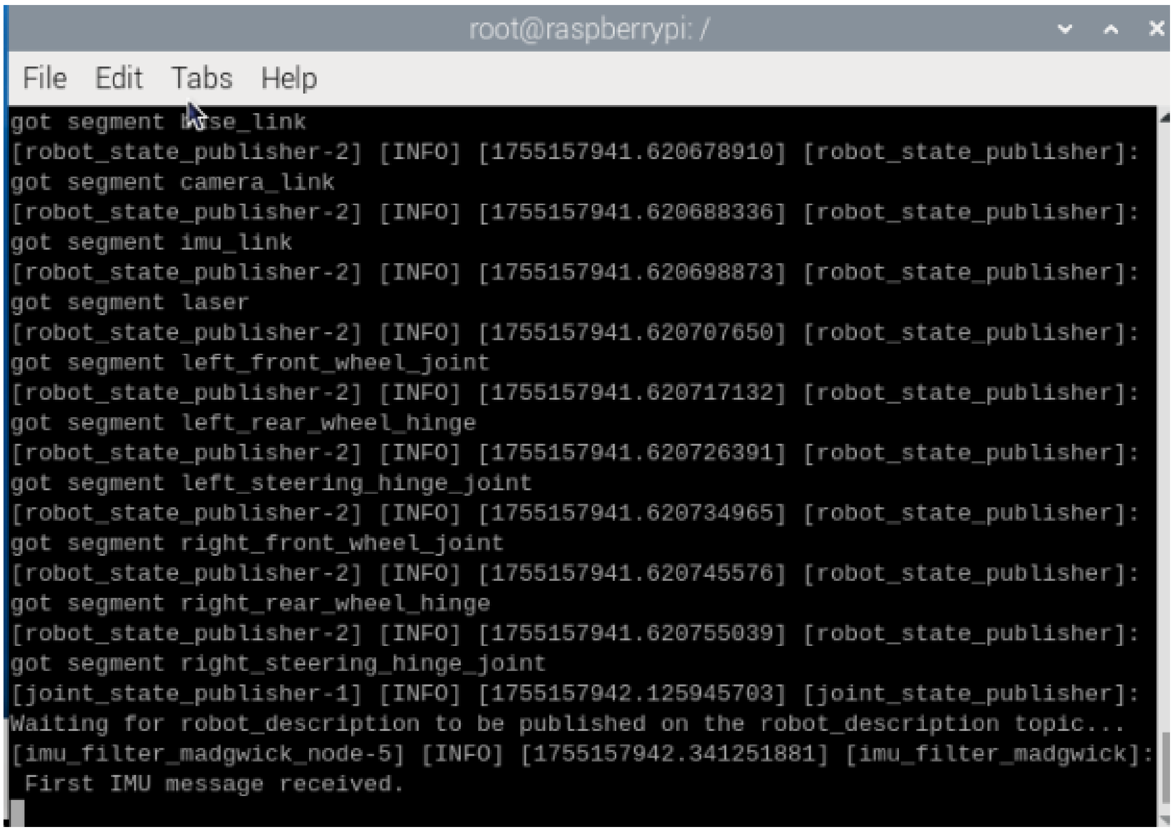
For Raspberry Pi and Jetson-Nano boards, you need to enter the Docker container first. For RDKX5 and Orin controllers, this is not necessary.

Enter the Docker container (see [Docker course] --- [4. Docker Startup Script] for steps).

All the following commands must be executed within the same Docker container **(see [Docker course] --- [3. Docker Submission and Multi-Terminal Access] for steps).**

Start chassis data, input in terminal:

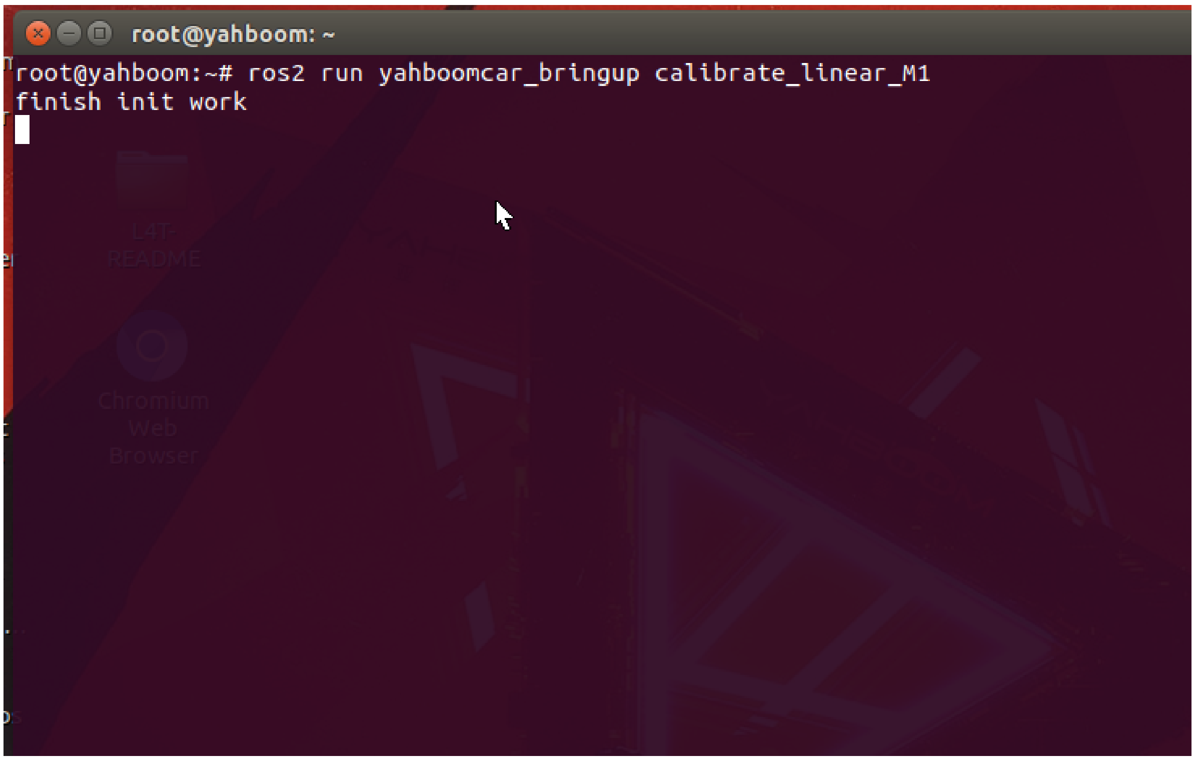
```
ros2 launch yahboomcar_bringup yahboomcar_bringup_M1_launch.py
```



```
got segment base_link
[robot_state_publisher-2] [INFO] [1755157941.620678910] [robot_state_publisher]:
got segment camera_link
[robot_state_publisher-2] [INFO] [1755157941.620688336] [robot_state_publisher]:
got segment imu_link
[robot_state_publisher-2] [INFO] [1755157941.620698873] [robot_state_publisher]:
got segment laser
[robot_state_publisher-2] [INFO] [1755157941.620707650] [robot_state_publisher]:
got segment left_front_wheel_joint
[robot_state_publisher-2] [INFO] [1755157941.620717132] [robot_state_publisher]:
got segment left_rear_wheel_hinge
[robot_state_publisher-2] [INFO] [1755157941.620726391] [robot_state_publisher]:
got segment left_steering_hinge_joint
[robot_state_publisher-2] [INFO] [1755157941.620734965] [robot_state_publisher]:
got segment right_front_wheel_joint
[robot_state_publisher-2] [INFO] [1755157941.620745576] [robot_state_publisher]:
got segment right_rear_wheel_hinge
[robot_state_publisher-2] [INFO] [1755157941.620755039] [robot_state_publisher]:
got segment right_steering_hinge_joint
[joint_state_publisher-1] [INFO] [1755157942.125945703] [joint_state_publisher]:
Waiting for robot_description to be published on the robot_description topic...
[imu_filter_madgwick_node-5] [INFO] [1755157942.341251881] [imu_filter_madgwick]:
 First IMU message received.
```

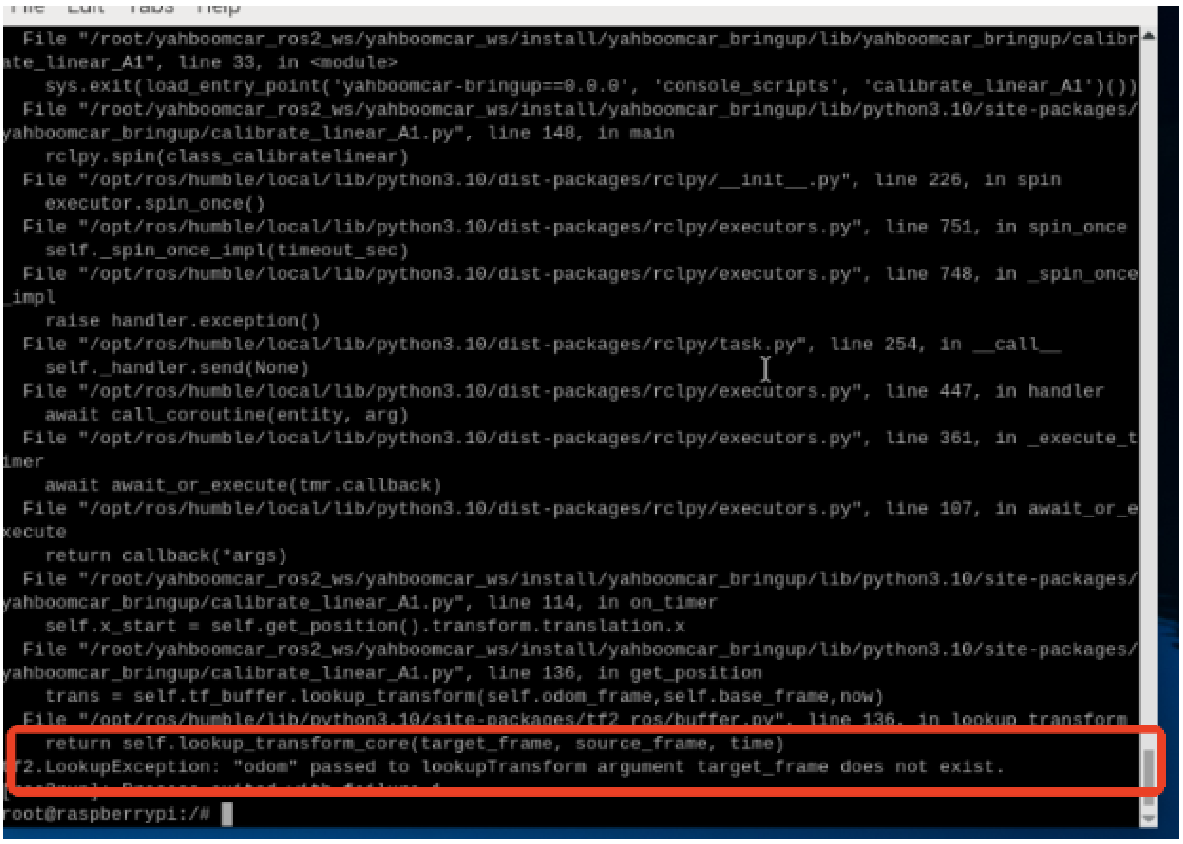
```
ros2 run yahboomcar_bringup calibrate_angular_M1
```

Successfully displayed the image below:



```
root@yahboom:~# ros2 run yahboomcar_bringup calibrate_linear_M1
finish init work
```

If the runtime error shows no tf transformation, press **ctrl+c** to exit the program and then run it again.

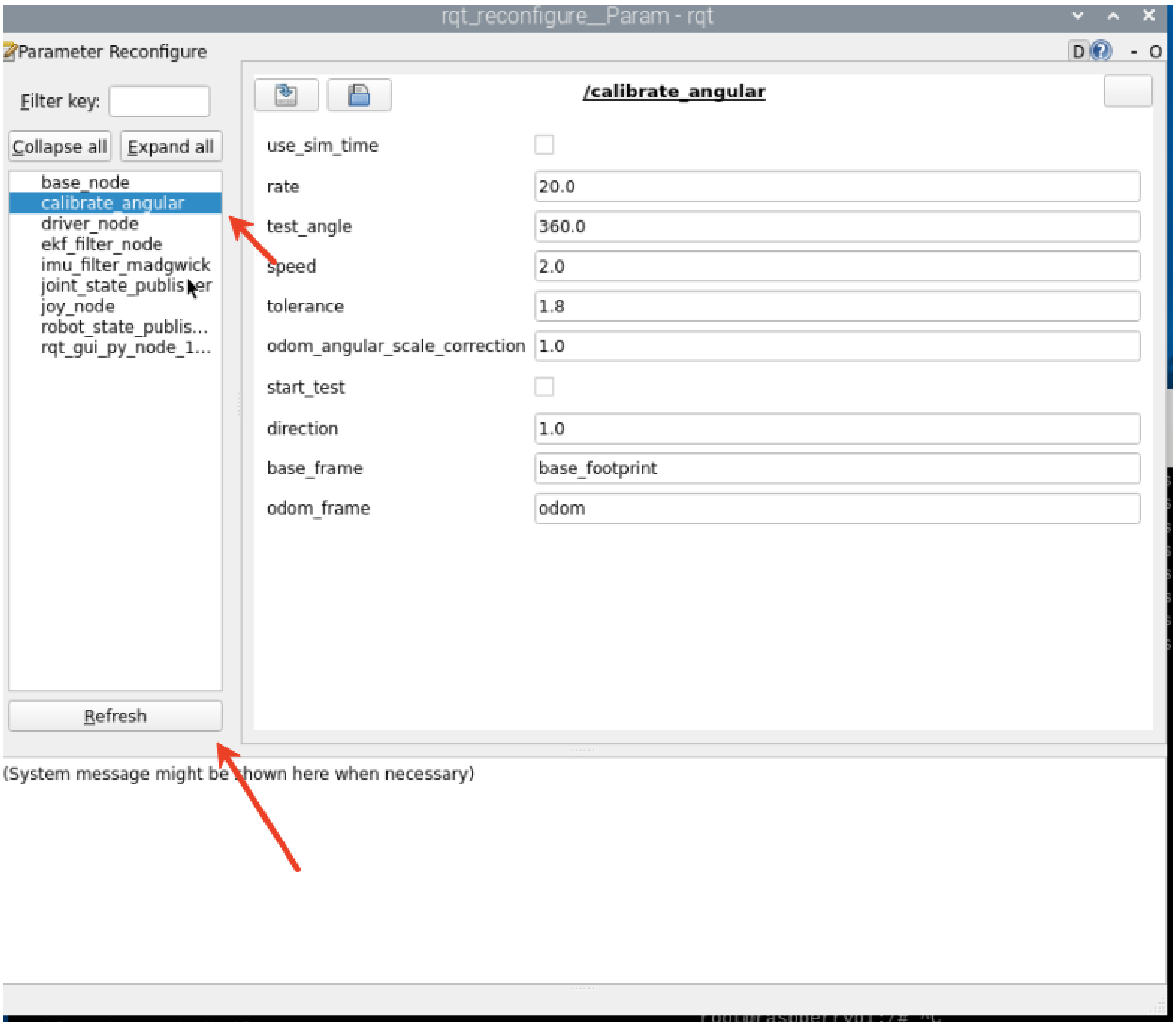


```
  File "/root/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_bringup/lib/yahboomcar_bringup/calibr
ate_linear_A1", line 33, in <module>
    sys.exit(load_entry_point('yahboomcar-bringup==0.0.0', 'console_scripts', 'calibrate_linear_A1')())
  File "/root/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_bringup/lib/python3.10/site-packages/
yahboomcar_bringup/calibrate_linear_A1.py", line 148, in main
    rclpy.spin(class_calibratelinear)
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/__init__.py", line 226, in spin
    executor.spin_once()
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/executors.py", line 751, in spin_once
    self._spin_once_impl(timeout_sec)
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/executors.py", line 748, in _spin_once
_impl
    raise handler.exception()
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/task.py", line 254, in __call__
    self._handler.send(None)
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/executors.py", line 447, in handler
    await call_coroutine(entity, arg)
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/executors.py", line 361, in _execute_t
imer
    await await_or_execute(tmr.callback)
  File "/opt/ros/humble/local/lib/python3.10/dist-packages/rclpy/executors.py", line 107, in await_or_e
xecute
    return callback(*args)
  File "/root/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_bringup/lib/python3.10/site-packages/
yahboomcar_bringup/calibrate_linear_A1.py", line 114, in on_timer
    self.x_start = self.get_position().transform.translation.x
  File "/root/yahboomcar_ros2_ws/yahboomcar_ws/install/yahboomcar_bringup/lib/python3.10/site-packages/
yahboomcar_bringup/calibrate_linear_A1.py", line 136, in get_position
    trans = self.tf_buffer.lookup_transform(self.odom_frame,self.base_frame,now)
  File "/opt/ros/humble/lib/python3.10/site-packages/tf2_ros/buffer.py", line 136, in lookup_transform
    return self.lookup_transform_core(target_frame, source_frame, time)
tf2.LookupException: "odom" passed to lookupTransform argument target_frame does not exist.
[ros2run]: Process exited with failure 1
root@raspberrypi:/#
```

Open the dynamic parameter tuner and run the following in the terminal:

```
ros2 run rqt_reconfigure rqt_reconfigure
```

Click the **calibrate_angular** node in the left-hand node options:


rqt_reconfigure__Param - rqt

Parameter Reconfigure

Filter key:

Collapse all | Expand all

base_node
calibrate_angular
driver_node
ekf_filter_node
imu_filter_madgwick
joint_state_publisher
joy_node
robot_state_publis...
rqt_gui_py_node_1...

Refresh

/calibrate_angular

use_sim_time	☐
rate	20.0
test_angle	360.0
speed	2.0
tolerance	1.8
odom_angular_scale_correction	1.0
start_test	☐
direction	1.0
base_frame	base_footprint
odom_frame	odom

(System message might be shown here when necessary)

Note: This node may not be visible initially. Click Refresh to see all nodes. The displayed **calibrate_angular** node is the node for calibrating angular velocity.

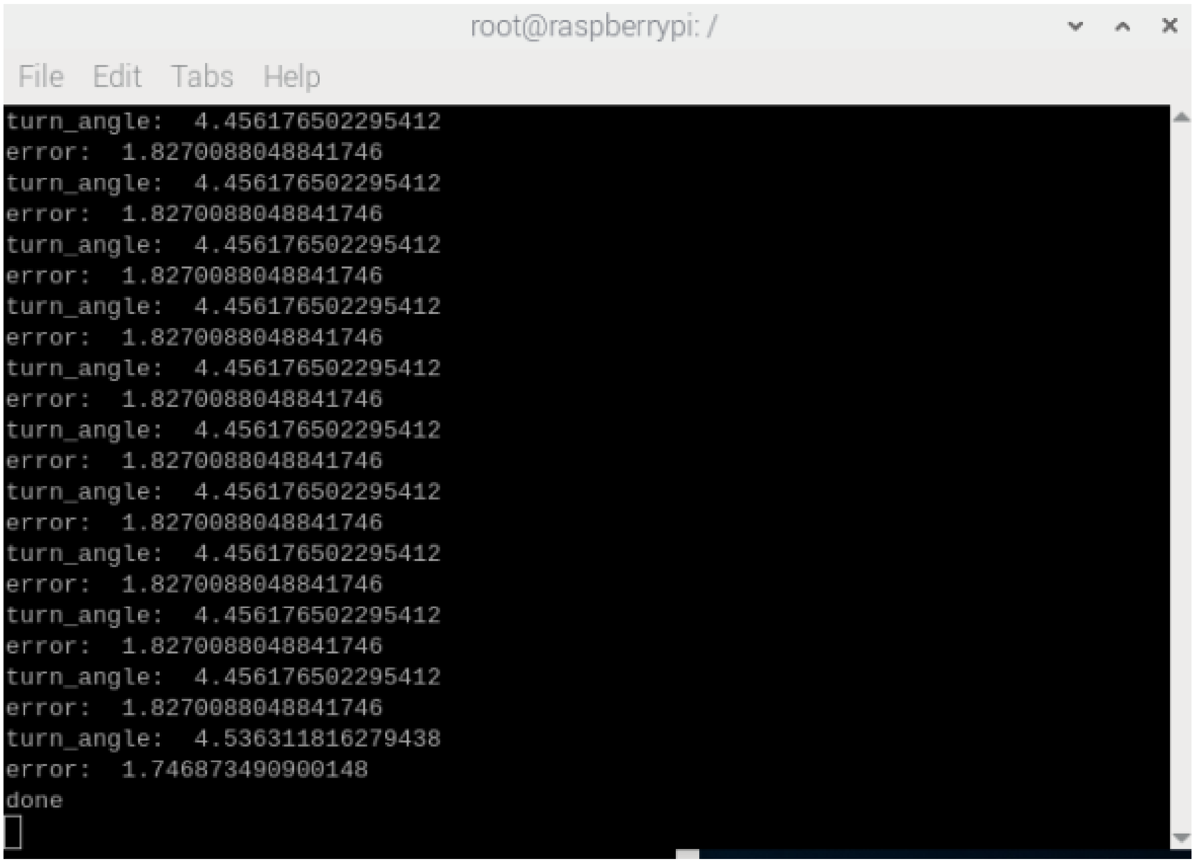
Other parameters in the rqt interface are explained below:

- test_angle: The angle for calibration testing; here, a 360-degree rotation is tested.
- speed: Angular velocity magnitude.
- tolerance: The tolerance for error.
- odom_angular_scale_correction: The linear velocity scale factor. Modify this value if the test results are unsatisfactory.
- start_test: Test switch.
- base_frame: The name of the base coordinate system.
- odom_frame: The name of the odometry coordinate system.

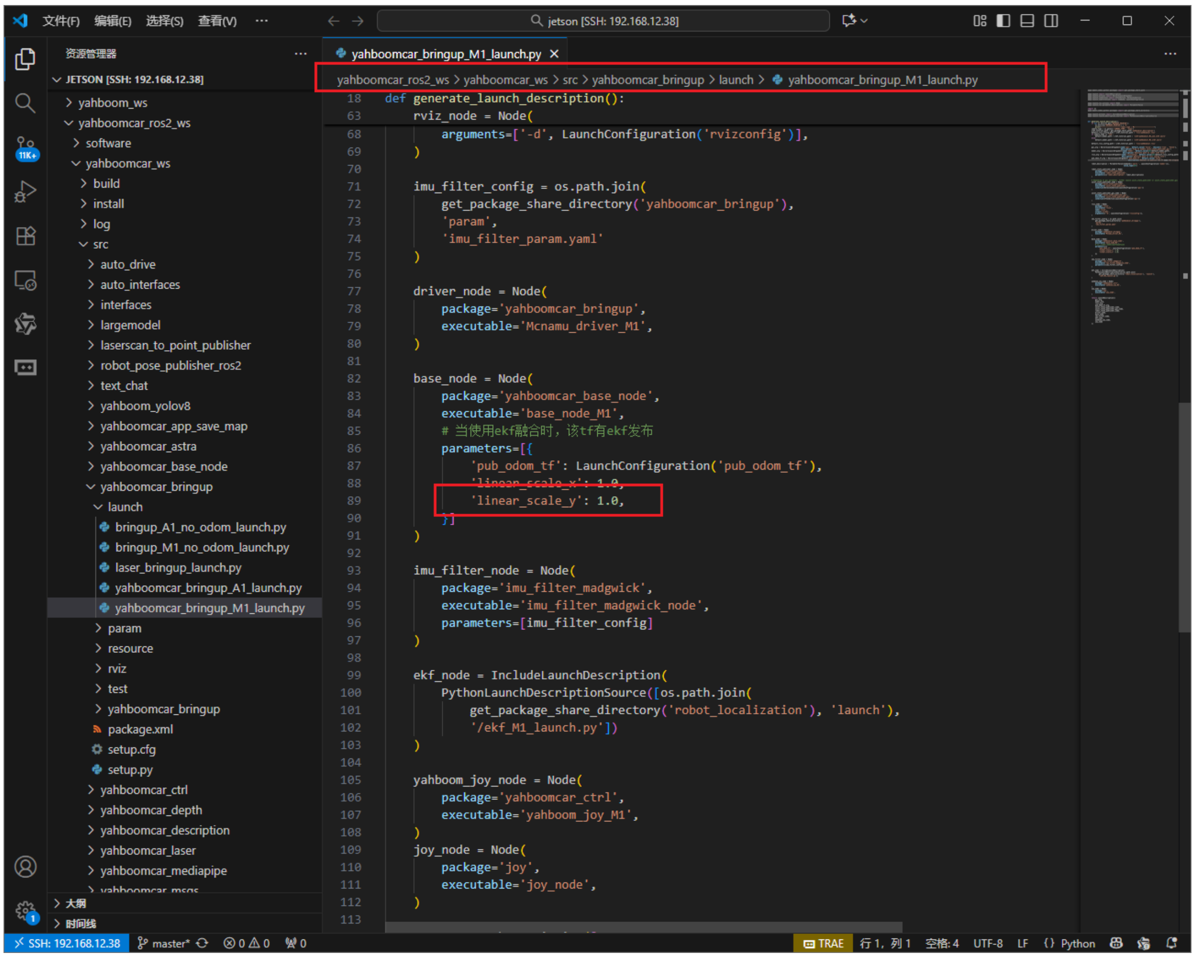
2.2 Starting Calibration

In the rqt_reconfigure interface, select the calibration_angular node. There is a **start_test** option below; click the box to the right of it to begin calibration.

After clicking start_test, the car will listen to the TF transforms of base_footprint and odom, calculate the theoretical rotation angle of the car, and issue a stopping command when the error is less than the tolerance.


```
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.456176502295412
error:  1.8270088048841746
turn_angle:  4.536311816279438
error:  1.746873490900148
done
```

After the test is complete, remember the value of 【odom_angular_scale_correction】 and modify the linear_scale_y parameter value in yahboomcar_bringup_M1_launch.py. Compile after modification

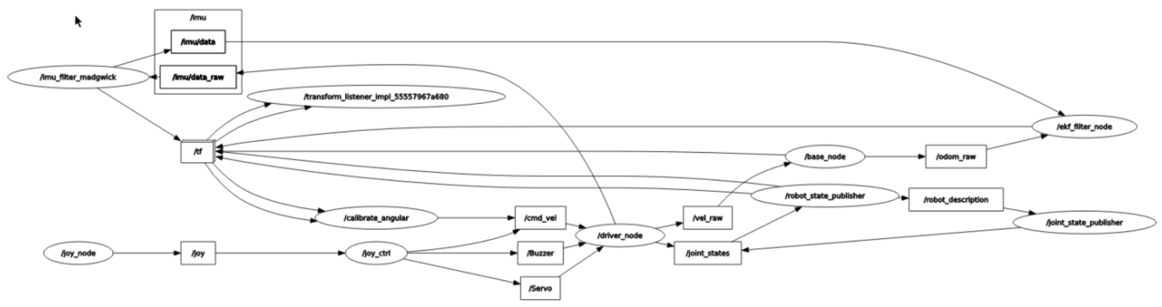

yahboomcar_ros2_ws > yahboomcar_ws > src > yahboomcar_bringup > launch > yahboomcar_bringup_M1_launch.py

```python
def generate_launch_description():
    rviz_node = Node(
        arguments=['-d', LaunchConfiguration('rvizconfig')],
    )

    imu_filter_config = os.path.join(
        get_package_share_directory('yahboomcar_bringup'),
        'param',
        'imu_filter_param.yaml'
    )

    driver_node = Node(
        package='yahboomcar_bringup',
        executable='Mcnamu_driver_M1',
    )

    base_node = Node(
        package='yahboomcar_base_node',
        executable='base_node_M1',
        # 当使用ekf融合时，该tf有ekf发布
        parameters=[{
            'pub_odom_tf': LaunchConfiguration('pub_odom_tf'),
            'linear_scale_x': 1.0,
            'linear_scale_y': 1.0,
        }]
    )

    imu_filter_node = Node(
        package='imu_filter_madgwick',
        executable='imu_filter_madgwick_node',
        parameters=[imu_filter_config]
    )

    ekf_node = IncludeLaunchDescription(
        PythonLaunchDescriptionSource([os.path.join(
            get_package_share_directory('robot_localization'), 'launch'),
            '/ekf_M1_launch.py'])
    )

    yahboom_joy_node = Node(
        package='yahboomcar_ctrl',
        executable='yahboom_joy_M1',
    )
    joy_node = Node(
        package='joy',
        executable='joy_node',
    )

```

3. View the node relationship graph

Open a terminal and enter the command:

```
ros2 run rqt_graph rqt_graph
```



In the above node relationship graph:

- The **imu_filter** node is responsible for filtering the raw IMU data from the chassis **/imu/data** and publishing the filtered data **/imu/data**.
- The **/ekf_filter_node** node subscribes to the raw odometer data from the chassis **/odom_raw** and the filtered IMU data **/imu/data**, performs data fusion, and publishes the **/odom** topic. The **calibrate_angular** node listens for the TensorFlow transformation from odom to base_footprint and publishes the /cmd_vel topic to control the robot's chassis movement.

4. Core Source Code Analysis

This program primarily utilizes TensorFlow to listen for coordinate transformations. By monitoring the coordinate transformations between base_footprint and odom, the robot knows "how far I've traveled/how many degrees I've turned."

Code path:

```
~/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_bringup/yahboomcar_bringup/cal
ibrate_angular_M1.py
```

The implementation of listening for TensorFlow coordinate transformations is the get_odom_angle method in the Calibrateangular class:

```python
def get_odom_angle(self):
     try:
        now = rclpy.time.Time()
        rot = self.tf_buffer.lookup_transform(
            self.base_frame,
            self.odom_frame,
            now,
            timeout=rclpy.duration.Duration(seconds=1.0))
        cacl_rot = PyKDL.Rotation.Quaternion(rot.transform.rotation.x,
rot.transform.rotation.y, rot.transform.rotation.z,
 rot.transform.rotation.w)
        #print("cacl_rot: ",cacl_rot)
        angle_rot = cacl_rot.GetRPY()[2]
        #print("angle_rot: ",angle_rot)

     except (LookupException, ConnectivityException, ExtrapolationException):
        # self.get_logger().info('transform not ready')
        return
```

The implementation of determining the robot chassis rotation angle and controlling its movement is achieved through the `on_timer` (timer callback function) method in the `Calibrateangular` class:

```
def on_timer(self):
    self.start_test = 
self.get_parameter('start_test').get_parameter_value().bool_value
    self.odom_angular_scale_correction = 
self.get_parameter('odom_angular_scale_correction').get_parameter_value().double
_value
    self.test_angle = 
self.get_parameter('test_angle').get_parameter_value().double_value
    self.test_angle = radians(self.test_angle) #角度转成弧度
    self.speed = self.get_parameter('speed').get_parameter_value().double_value
    move_cmd = Twist()
    self.test_angle *= self.reverse
    #self.test_angle *= self.reverse
    #self.error = self.test_angle - self.turn_angle
    if self.start_test:
        self.error = self.turn_angle - self.test_angle
        if abs(self.error) > self.tolerance  :
            #move_cmd.linear.x = 0.2
            move_cmd.angular.z = copysign(self.speed, self.error)
            #print("angular: ",move_cmd.angular.z)
            self.cmd_vel.publish(move_cmd)
            self.odom_angle = self.get_odom_angle()
            self.delta_angle = self.odom_angular_scale_correction * 
self.normalize_angle(self.odom_angle - self.first_angle)
            #print("delta_angle: ",self.delta_angle)
            self.turn_angle += self.delta_angle
            print("turn_angle: ",self.turn_angle,flush=True)
            #self.error = self.test_angle - self.turn_angle
            print("error: ",self.error,flush=True)
            self.first_angle = self.odom_angle

            #print("first_angle: ",self.first_angle)
        else:
            self.error = 0.0
            self.turn_angle = 0.0
            print("done",flush=True)
            self.first_angle = 0
            self.reverse = -self.reverse
            self.start_test  = 
rclpy.parameter.Parameter('start_test',rclpy.Parameter.Type.BOOL,False)
            all_new_parameters = [self.start_test]
            self.set_parameters(all_new_parameters)
    else:
        self.error = 0.0
        self.cmd_vel.publish(Twist())
        self.turn_angle = 0.0
        self.start_test  = 
rclpy.parameter.Parameter('start_test',rclpy.Parameter.Type.BOOL,False)

        all_new_parameters = [self.start_test]
        self.set_parameters(all_new_parameters)
```