

5. Robot state estimation

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imu_calib: https://github.com/dpkoch/imu_calib

imu_filter_madgwick: https://wiki.ros.org/imu_filter_madgwick

robot_localization: http://docs.ros.org/en/melodic/api/robot_localization/html/index.html

5.1. Basic use

- start up

jetson motherboard/Raspberry Pi 4B

```
roslaunch transbot_bringup bringup.launch robot_model:=camera # Ordinary camera version
```

Raspberry Pi 5

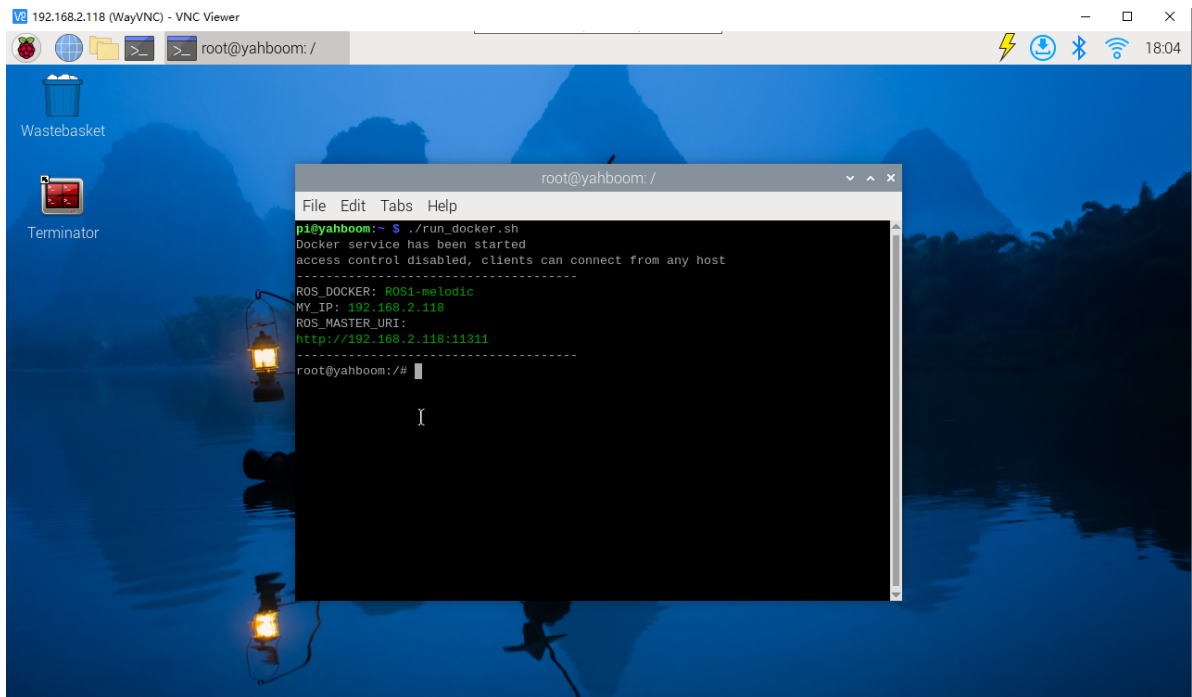
Before running, please confirm that the large program has been permanently closed

Enter docker

Note: If there is a terminal that automatically starts docker, or there is a docker terminal that has been opened, you can directly enter the docker terminal to run the command, and there is no need to manually start docker

Start docker manually

```
./run_docker.sh
```



```
roslaunch transbot_bringup bringup.launch robot_model:=camera # Ordinary camera version
```

When starting with bringup.launch, be sure to change the parameter [robot_model] to the corresponding camera model. For example, the default is a high frame rate camera, [default="camera"]. You do not need to add parameters when you start it next time.

```
<arg name="robot_model" default="camera" doc="robot_model type [astra,camera]"/>
```

- launch file parsing. See function package: ~/transbot_ws/src/transbot_bringup

-rviz

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```
roslaunch transbot_bringup view_odom.launch
```

Raspberry Pi 5

Enter the same docker from multiple terminals

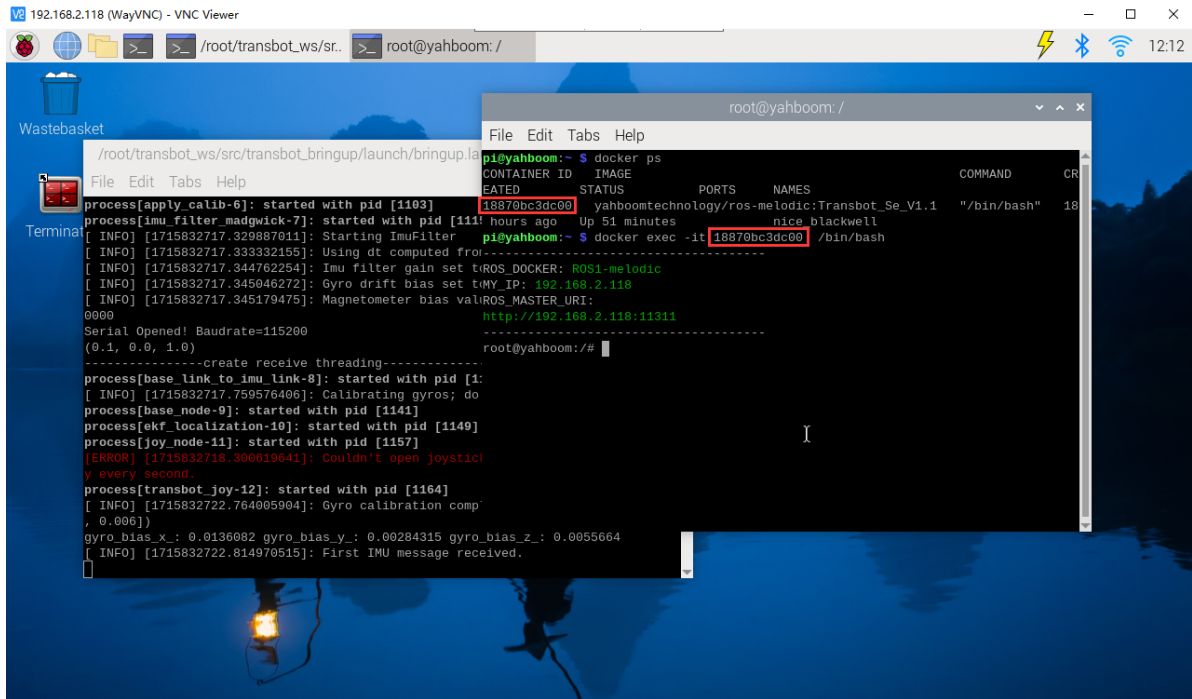
Keep the program of the previous docker terminal running and open a new terminal

Enter the following command

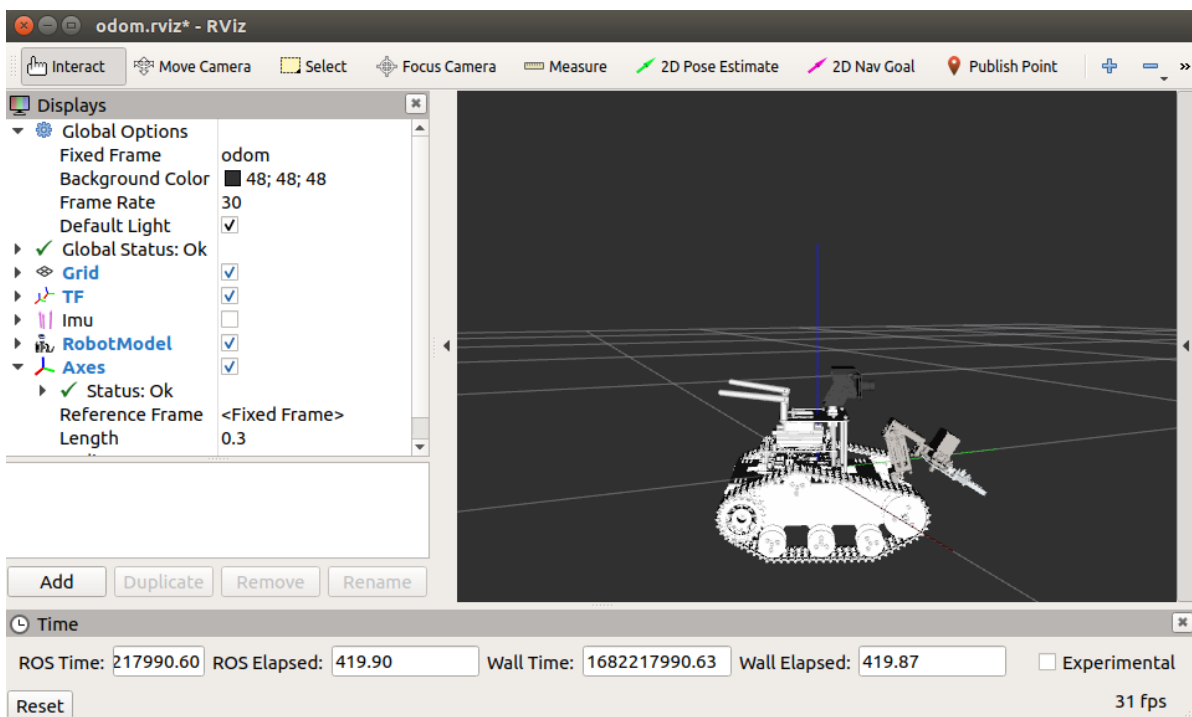
```
docker ps
```

Enter the same docker and use the following 18870bc3dc00 to modify the ID displayed on the actual terminal.

```
docker exec -it 18870bc3dc00 /bin/bash
```



```
roslaunch transbot_bringup view_odom.launch
```



- View node graph

jetson/Raspberry Pi 4B

```
rqt_graph
```

Raspberry Pi 5

Enter the same docker from multiple terminals

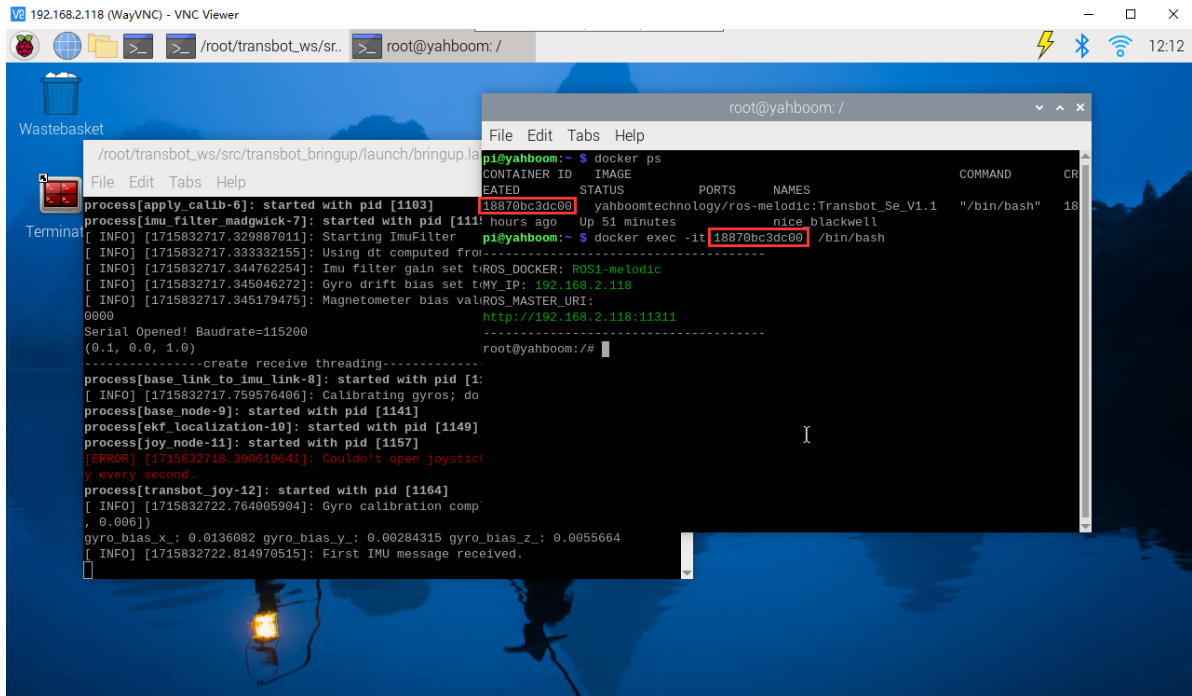
Keep the program of the previous docker terminal running and open a new terminal

Enter the following command

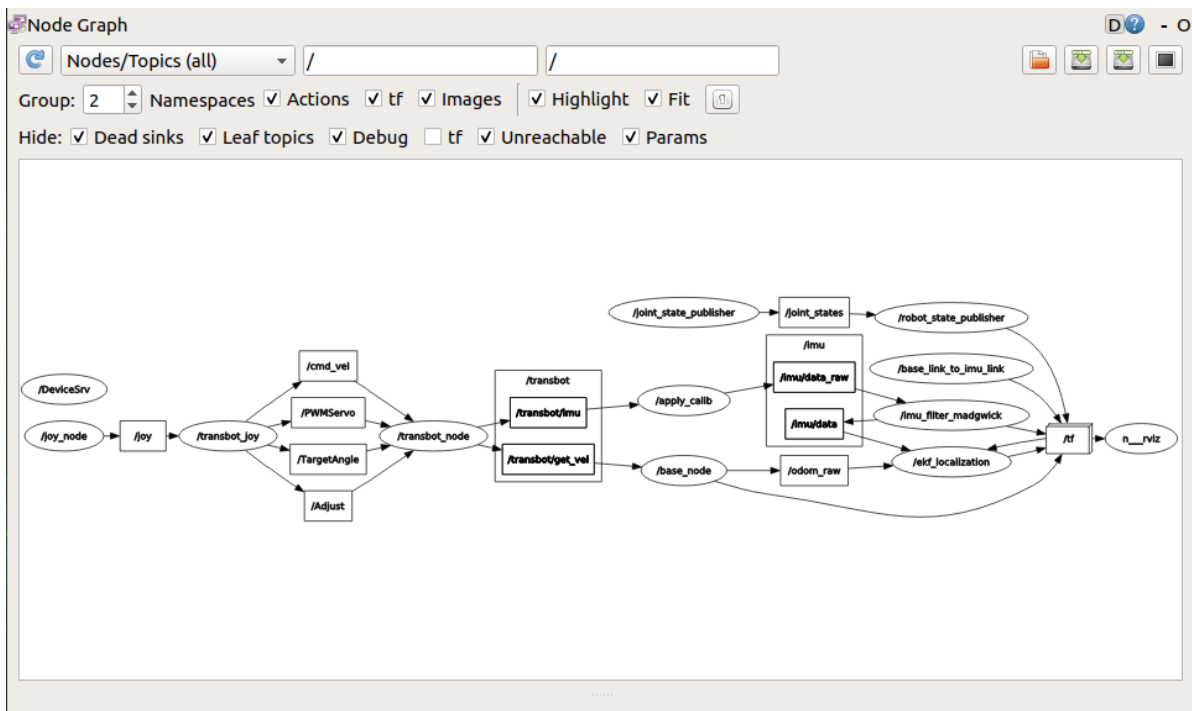
```
docker ps
```

Enter the same docker and use the following 18870bc3dc00 to modify the ID displayed on the actual terminal.

```
docker exec -it 18870bc3dc00 /bin/bash
```



```
rqt_graph
```



tf tree

jetson motherboard/Raspberry Pi 4B

```
roslaunch rqt_tf_tree rqt_tf_tree
```

Raspberry Pi 5

Enter the same docker from multiple terminals

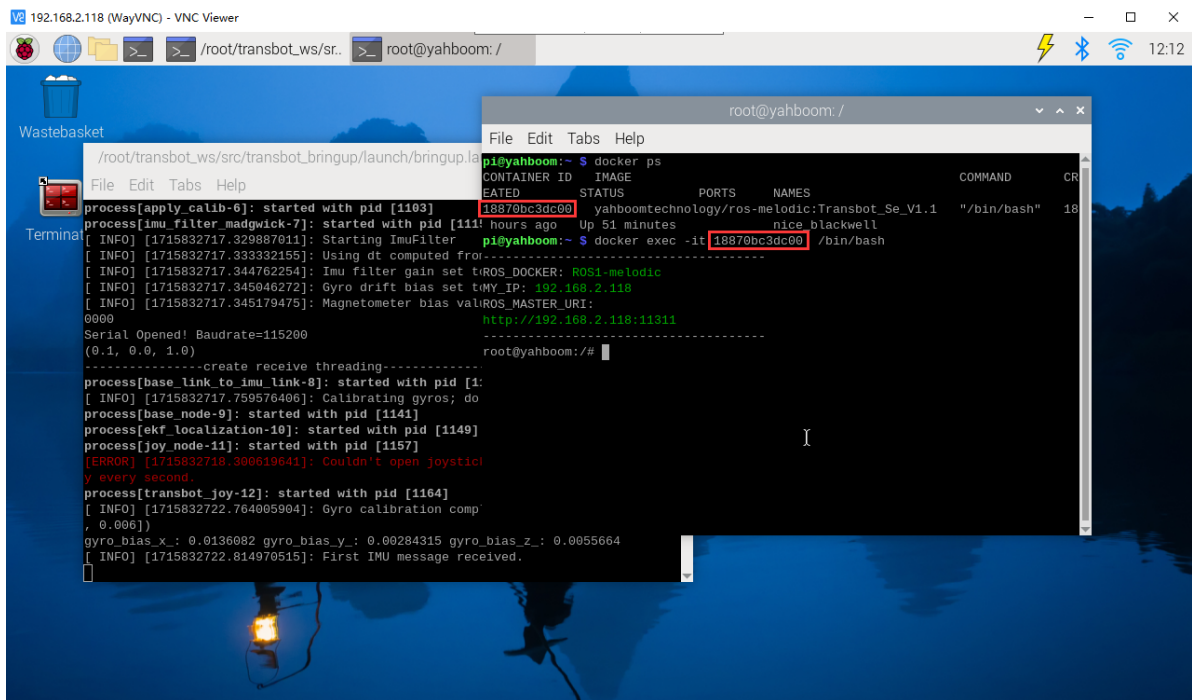
Keep the program of the previous docker terminal running and open a new terminal

Enter the following command

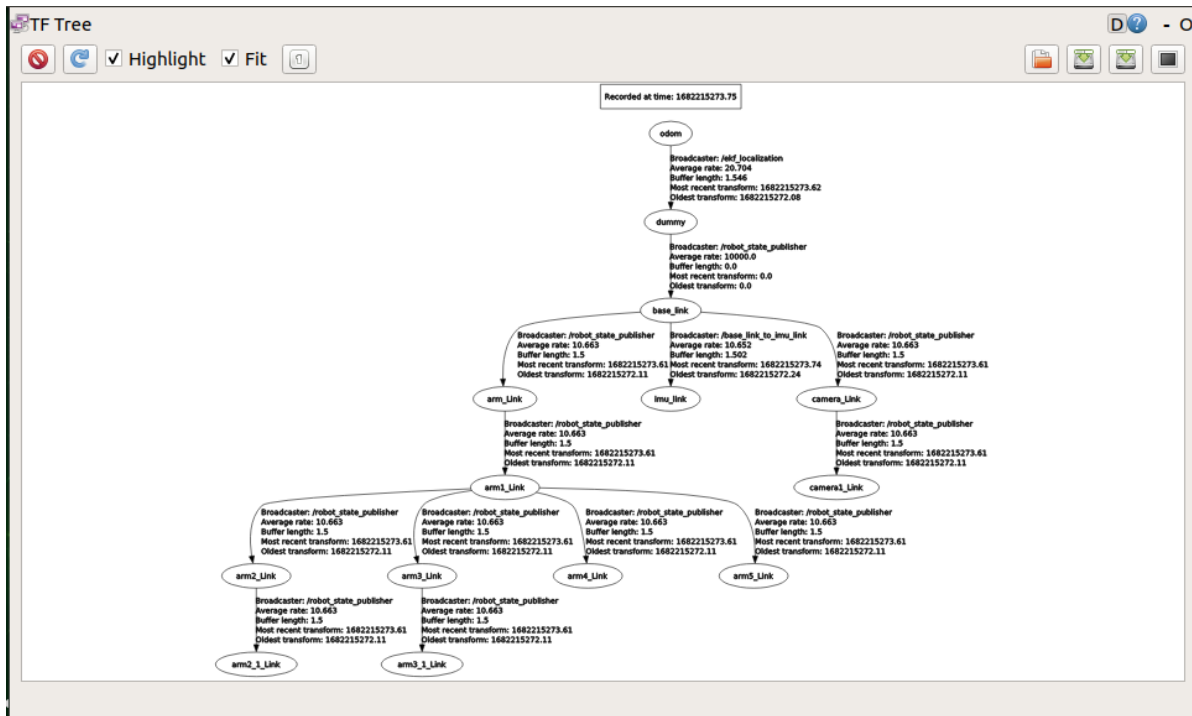
```
docker ps
```

Enter the same docker and use the following 18870bc3dc00 to modify the ID displayed on the actual terminal.

```
docker exec -it 18870bc3dc00 /bin/bash
```



```
roslaunch rqt_tf_tree rqt_tf_tree
```



5.2. Main nodes

5.2.1、transbot_node

Topic	Type	Parsing
/transbot/imu	sensor_msgs/Imu	The most primitive imu data of the car
/transbot/get_vel	geometry_msgs/Twist	The most original odometer information of the car

5.2.2、apply_calib

The IMU in Yahboom's image system has been calibrated. If you are using a Yahboom image file, no calibration is required.

This course is for reference.

1) Topic

/	Topic name	Type	Parsing
Subscribed	/raw_imu	sensor_msgs/Imu	Original, uncalibrated IMU measurement
Published	/imu/data_raw	sensor_msgs/Imu	Corrected, calibrated IMU measurement value

2) Parameter

Parameter name	Type	Defaults value	Parsing
~calib_file	string	"imu_calib.yaml"	Read calibration parameter file
~calibrate_gyros	bool	true	Whether to calculate the deviation of the gyro and subtract the deviation when starting
~gyro_calib_samples	int	100	Number of measurements used to calculate gyro deviation

5.2.3、imu_filter_madgwick

1) Intrudction

IMU refers to a six-axis sensor, including gyroscope and accelerometer.

MARG refers to a nine-axis sensor, and a magnetometer is added to the IMU.

```
IMU = gyroscope + accelerometer  
MARG(Magnetic, Angular Rate, and Gravity) = gyroscope + accelerometer +  
magnetometer
```

2) Topic

/	Topic name	Type	Parsing
Subscribed	/imu/data_raw	sensor_msgs/Imu	Message of the calibrated IMU data, including angular velocity and linear acceleration
Subscribed	/imu/mag	sensor_msgs/MagneticField	[Optional] Magnetometer, will be affected by magnetic field
Published	/imu/data	sensor_msgs/Imu	Fusion of Imu information.

3) Parameter

Parameter name	Type	Defaults	Parsing
~gain	double	0.1	<p>The gain of the filter.</p> <p>The higher the value, the faster the convergence speed, but the greater the noise.</p> <p>The lower the value, the slower the convergence speed, but the smoother the signal. Range: 0.0 to 1.0</p>
~zeta	double	0.0	<p>Gyro drift gain (about rad/s). Range: -1.0 to 1.0</p>
~mag_bias_x	double	0.0	<p>Magnetometer bias (hard iron correction), x component. Range: -10.0 to 10.0</p>
~mag_bias_y	double	0.0	<p>Magnetometer bias (hard iron correction), y component. Range: -10.0 to 10.0</p>
~mag_bias_z	double	0.0	<p>Magnetometer bias (hard iron correction), z component. Range: -10.0 to 10.0</p>
~orientation_stddev	double	0.0	<p>The standard deviation of the direction estimate. Range: 0.0 to 1.0</p>
~world_frame	string	"nwu"	<p>The world frame that indicates the direction.</p> <p>The old default value is "nwu" (northwest up).</p> <p>New deployments should use "enu".</p> <p>Valid values: "nwu", "enu", "ned".</p>
~use_mag	bool	true	<p>Whether to use magnetic field data in data fusion.</p>
~use_magnetic_field_msg	bool	false	<p>If set to true, subscribe to /imu and /mag topics as sensor_msgs/MagneticField; if set to false (it not recommended), use geometry_msgs/Vector3Stamped</p>

Parameter name	Type	Defaults	Parsing
~fixed_frame	string	odom	The parent coordinate system to be used in publishing
~publish_tf	bool	false	Whether to publish the TF transformation indicating the direction of the IMU, as the pose of the IMU; Use the fixed coordinate system as the parent coordinate system, and input the imu information as the child coordinate system
~reverse_tf	bool	false	If set to true, the transformation from the imu coordinate system to the fixed coordinate system will be issued.
~constant_dt	double	0.0	The dt to be used; if it is 0.0 (default value), the dynamic value of dt is calculated from the start of the message.
~publish_debug_topics	bool	false	If set to true, two debugging topics are posted.
~stateless	bool	false	If set to true, the filtered direction will not be published. Instead, stateless estimates of bearing are issued based only on the latest accelerometer (and optionally magnetometer) readings. Used for debugging.
~remove_gravity_vector	bool	false	If set to true, the gravity vector is subtracted from the acceleration field in the published IMU message.

5.2.4、robot_localization

1) Introduction

`robot_localization` is a collection of state estimation nodes. Each node is an implementation of a nonlinear state estimator for robots moving in 3D space. It includes two state estimation nodes `ekf_localization_node` and `ukf_localization_node`. In addition, `robot_localization` provides `navsat_transform_node`, which helps to integrate GPS data.

`ekf_localization_node` is an implementation of [Extended Kalman Filter](#). It uses an omnidirectional motion model to predict the state in time, and uses the sensor data to correct the estimated value of the prediction.

`ukf_localization_node` is an implementation of [Unscented Kalman Filter](#). It uses a set of carefully selected sigma points to project the state through the same motion model used in EKF, and then uses these projected sigma points to recover the state estimation and covariance. This eliminates the use of the Jacobian matrix and makes the filter more stable. However, compared with `ekf_localization_node`, it is also more computationally cumbersome.

topic

/	Topic	Type	Parsing
Subscribed	/imu/data	sensor_msgs/Imu	Filtered imu information
Subscribed	/odom_raw	nav_msgs/Odometry	Odometer information
Published	/odom	nav_msgs/Odometry	Converged odometer information
Published	/tf	tf2_msgs/TFMessage	Coordinate system information

2) Parameter

- frequency: the true frequency (in Hz) at which the filter generates the estimated state value.
Note: The filter will only start calculation after it receives at least one message from one of the inputs.
- [sensor]: For each sensor, the user needs to define this parameter according to the message type. The index of each parameter name starts from 0 (for example odom0, odom1, etc.) and must be defined in order (for example, if pose1 has not been defined, do not use pose0 and pose2). The value of each parameter is the topic name of the sensor.

- odom0: /odom_raw
imu0: /imu/data

- [sensor]_differential: For each of the above-defined sensor messages containing pose information, the user can specify whether the pose variables should be integrated differentially. If the given value is set to true, then for the measurement from the relevant sensor at time t, we will first subtract the measured value at time t-1, and then convert the resulting value to speed.

```
~odomN_differential
~imuN_differential
~poseN_differential
```

- [sensor]_relative: If this parameter is set to true, any measurement value from the sensor will be fused relative to the first measurement value received from the sensor. This is useful in the following situations, for example, if you want the state estimate to always start at (0,0,0), and the roll, pitch, and yaw angle values are (0,0,0).

```
~odomN_relative
~imuN_relative
~poseN_relative
```

- `two_d_mode`: If your robot is running in a flat environment and can ignore subtle changes in the ground (as reported by the IMU), set it to true. It merges all 3D variables (Z, roll, pitch and their respective speed and acceleration) into a value of 0. This ensures that the covariance of these values does not explode, and at the same time ensures that the state estimate of your robot is still fixed on the X-Y plane.
- `odom0_config`: [false, false, false, false, false, false, true, true, false, false, false, true, false, false, false]

`odom0_config`: [false, false, false, false, false, false, true, true, false, false, false, true, false, false, false]

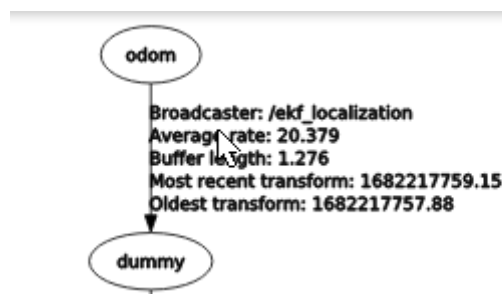
The order of Boolean values is: [[X], [Y], [Z], [roll], [pitch], [yaw], [X'], [Y'], [Z'], [roll'], [Pitch'], [yaw'], [X''], [Y''], [Z''], [roll''], [pitch''], [yaw'']]. The user must specify which variables of these messages should be incorporated into the final state estimate.

3) Transformation of release

If the user's `world_frame` parameter is set to the value of `odom_frame`, the conversion will be published from the coordinate system given by the `odom_frame` parameter to the coordinate system given by the `base_link_frame` parameter. If the user's `world_frame` parameter is set to the value of `map_frame`, the conversion will be published from the coordinate system given by the `map_frame` parameter to the coordinate system given by the `odom_frame` parameter.

For example, we set to publish the conversion from the coordinate system given by the `[odom_frame]` parameter to the coordinate system given by the `[base_link_frame]` parameter.

```
odom_frame: odom
base_link_frame: base_footprint
world_frame: odom
```



5.3. Precautions

While starting the robot, the robot is stationary. If the buzzer keeps ringing, there are two possibilities:

- The posture of the robot is (bias = [0.0, 0.0, 0.0]);
- The system detects that the robot is in free fall.

Solution:

- Close the terminal and restart the command;
- Close the terminal, press the PCB board reset button [RESET] and then restart the command.

