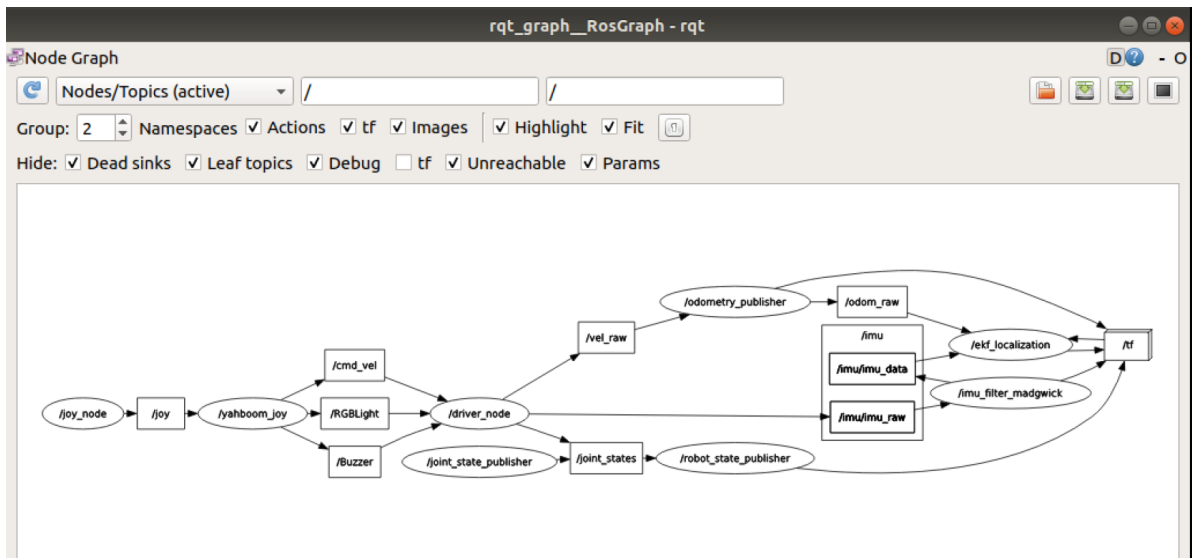


2) 、 View Node Graph

```
roslaunch rqt_graph rqt_graph
```



4.1.2、 launch file analysis

In the bringup.launch file, there are several important nodes

1) 、 /drive_node

This node mainly publishes /imu/imu_raw and /vel_raw data, terminal input

```
roslaunch rqt_graph rqt_graph
```

```

rojetson@yahboom:~$ rosnodetools info /driver_node
-----
Node [/driver_node]
Publications:
  * /driver_node/parameter_descriptions [dynamic_reconfigure/ConfigDescription]
  * /driver_node/parameter_updates [dynamic_reconfigure/Config]
  * /redition [std_msgs/Float32]
  * /imu/imu_raw [sensor_msgs/Imu]
  * /joint_states [sensor_msgs/JointState]
  * /mag/mag_raw [sensor_msgs/MagneticField]
  * /rosout [roscpp_msgs/Log]
  * /vel_raw [geometry_msgs/Twist]
  * /voltage [std_msgs/Float32]
Subscriptions:
  * / buzzer [unknown type]
  * /rcbLight [unknown type]
  * /cmd_vel [unknown type]
Services:
  * /driver_node/get_loggers
  * /driver_node/set_logger_level
  * /driver_node/set_parameters
contacting node http://192.168.2.98:40137/ ...
Pid: 972
Connections:
  * topic: /joint_states
    * to: /robot_state_publisher
      * direction: outbound (36531 - 192.168.2.98:49708) [27]
      * transport: TCPROS
  * topic: /vel_raw
    * to: /odometry_publisher
      * direction: outbound (36531 - 192.168.2.98:49712) [24]
      * transport: TCPROS
  * topic: /rosout
    * to: /rosout
      * direction: outbound (36531 - 192.168.2.98:49706) [9]
      * transport: TCPROS
  * topic: /imu/imu_raw
    * to: /imu_filter_madgwick
      * direction: outbound (36531 - 192.168.2.98:49710) [23]
      * transport: TCPROS

```

As can be seen,

- The /driver_node node publishes the /imu/imu_raw topic data to the /imu_filter_madgwick node, which filters and fuses the imu data;
- The /driver_node node publishes the /vel_raw topic data to the /odometry_publisher node. After the latter is integrated, the /odom_raw data is published;

2) 、 /odometry_publisher

This node mainly receives the vel_raw topic data sent by the /driver_node node, publishes the /odom_raw topic data to /ekf_localization, and publishes the /tf topic data to other nodes, terminal input,

```
roslaunch rosbash /odometry_publisher
```

```

jetson@yahboom:~$ rosnodetools info /odometry_publisher
-----
Node [/odometry_publisher]
Publications:
  * /odom_raw [nav_msgs/Odometry]
  * /rosout [roscpp_msgs/Log]
  * /tf [tf2_msgs/TFMessage]
Subscriptions:
  * /vel_raw [geometry_msgs/Twist]
Services:
  * /odometry_publisher/get_loggers
  * /odometry_publisher/set_logger_level
contacting node http://192.168.2.98:43625/ ...
Pid: 974
Connections:
  * topic: /rosout
    * to: /rosout
      * direction: outbound (36909 - 192.168.2.98:58714) [10]
      * transport: TCPROS
  * topic: /tf
    * to: /ekf_localization
      * direction: outbound (36909 - 192.168.2.98:58902) [12]
      * transport: TCPROS
  * topic: /tf
    * to: /odom_rviz
      * direction: outbound (36909 - 192.168.2.98:59218) [14]
      * transport: TCPROS
  * topic: /tf
    * to: /rqt_gui_py_node_5177
      * direction: outbound (36909 - 192.168.2.98:59390) [15]
      * transport: TCPROS
  * topic: /odom_raw
    * to: /ekf_localization
      * direction: outbound (36909 - 192.168.2.98:59100) [13]
      * transport: TCPROS
  * topic: /vel_raw
    * to: /driver_node (http://192.168.2.98:40137/)
      * direction: inbound (49712 - 192.168.2.98:36531) [16]
      * transport: TCPROS

```

3) 、 /imu_filter_madgwick

This node mainly filters and fuses imu data, and then publishes the processed /imu/imu_data topic data to the /ekf_localization node to receive and publish /tf data to other nodes, terminal input,

```
roslaunch rosbash /imu_filter_madgwick
```

```

* transport: TCPROS
* topic: /tf
* to: /ekf_localization
* direction: outbound (57775 - 192.168.2.98:40314) [12]
* transport: TCPROS
* topic: /tf
* to: /odom_rviz
* direction: outbound (57775 - 192.168.2.98:40630) [14]
* transport: TCPROS
* topic: /tf
* to: /rqt_gui_py_node_5177
* direction: outbound (57775 - 192.168.2.98:40802) [15]
* transport: TCPROS
* topic: /imu/imu_data
* to: /ekf_localization
* direction: outbound (57775 - 192.168.2.98:40512) [13]
* transport: TCPROS
* topic: /imu/imu_raw
* to: /driver_node (http://192.168.2.98:40137/)
* direction: inbound (40710 - 192.168.2.98:36531) [16]
* transport: TCPROS

```

4) 、 /ekf_localization

This node mainly integrates imu data and odom data and publishes tf data, terminal input,

```
rosnode info /ekf_localization
```

```

contacting node http://192.168.2.98:42883/ ...
Pid: 993
Connections:
* topic: /rosout
* to: /rosout
* direction: outbound (46483 - 192.168.2.98:49346) [11]
* transport: TCPROS
* topic: /tf
* to: /ekf_localization
* direction: outbound
* transport: INTRAPROCESS
* topic: /tf
* to: /odom_rviz
* direction: outbound (46483 - 192.168.2.98:49800) [12]
* transport: TCPROS
* topic: /tf
* to: /rqt_gui_py_node_5177
* direction: outbound (46483 - 192.168.2.98:49906) [14]
* transport: TCPROS
* topic: /tf
* to: /ekf_localization (http://192.168.2.98:42883/)
* direction: inbound
* transport: INTRAPROCESS
* topic: /tf
* to: /robot_state_publisher (http://192.168.2.98:45697/)
* direction: inbound (55732 - 192.168.2.98:52579) [17]
* transport: TCPROS
* topic: /tf
* to: /odometry_publisher (http://192.168.2.98:43625/)
* direction: inbound (58902 - 192.168.2.98:36909) [18]
* transport: TCPROS
* topic: /tf
* to: /imu_filter_madgwick (http://192.168.2.98:40889/)
* direction: inbound (40314 - 192.168.2.98:57775) [19]
* transport: TCPROS
* topic: /tf_static
* to: /robot_state_publisher (http://192.168.2.98:45697/)
* direction: inbound (55730 - 192.168.2.98:52579) [16]
* transport: TCPROS
* topic: /odom_raw
* to: /odometry_publisher (http://192.168.2.98:43625/)
* direction: inbound (59100 - 192.168.2.98:36909) [13]
* transport: TCPROS
* topic: /imu/imu_data
* to: /imu_filter_madgwick (http://192.168.2.98:40889/)
* direction: inbound (40512 - 192.168.2.98:57775) [10]
* transport: TCPROS

```

Next, we describe these nodes in detail.

4.1.3、 imu_filter_madgwick

1) 、 Introduction

IMU refers to a six-axis sensor that includes a gyroscope and an accelerometer. MARG refers to a nine-axis sensor that adds a magnetometer to the IMU.

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

Madgwick is an Orientation Filter that filters and fuses raw data from IMU devices. It fuses angular velocity, acceleration, and (optionally) magnetometer readings from generic IMU devices into orientation quaternions, and publishes the fused data on the IMU topic without considering the entire IMU integration process.

2) 、 Topic

/	Topic Name	Type	Attributes
Subscribed	/imu/data_raw	sensor_msgs/Imu	校准后的IMU数据的消息，包括角速度和线加速度
Subscribed	/imu/mag	sensor_msgs/MagneticField	[可选]磁力计，会受磁场影响
Published	/imu/data	sensor_msgs/Imu	融合的Imu信息。

3) 、 parameter

Topic Name	Type	Defaults	Attributes
~gain	double	0.1	filter gain Higher values result in faster convergence but more noise. The lower the value, the slower the convergence, but the smoother the signal. Range: 0.0 to 1.0
~zeta	double	0.0	Gyro drift gain (about rad/s). Range: -1.0 to 1.0
~mag_bias_x	double	0.0	Magnetometer bias (hard iron corrected), x-component. Range: -10.0 to 10.0
~mag_bias_y	double	0.0	Magnetometer bias (hard iron correction), y component. Range: -10.0 to 10.0
~mag_bias_z	double	0.0	Magnetometer bias (hard iron correction), z component. Range: -10.0 to 10.0
~orientation_stddev	double	0.0	The standard deviation of the orientation estimate. Range: 0.0 to 1.0
~world_frame	string	"nwu"	World frame indicating direction (see REP-145). The old default was "nwu" (northwest up). New deployments should use "enu". Valid values: "nwu", "enu", "ned".
~use_mag	bool	true	Whether to use magnetic field data in data fusion.
~use_magnetic_field_msg	bool	false	If set to true, subscribe /imu, /mag topics as sensor_msgs/MagneticField; if set to false (deprecated), use geometry_msgs/Vector3Stamped
~fixed_frame	string	odom	Parent coordinate system to use in publishing
~publish_tf	bool	false	Whether to publish the TF transformation representing the direction of the IMU as the pose of the IMU; use the fixed coordinate system as the parent coordinate system, and the input imu information as the child coordinate system

Topic Name	Type	Defaults	Attributes
~reverse_tf	bool	false	If set to true, the transformation from the imu coordinate system to the fixed coordinate system is published, not the other way around.
~constant_dt	double	0.0	The dt to use; if 0.0 (default), the dt dynamic value is calculated from the message start position.
~publish_debug_topics	bool	false	If set to true, two debug topics are published.
~stateless	bool	false	If set to true, the filtered orientation is not published. Instead, a stateless estimate of orientation is published based only on the latest accelerometer (and optional magnetometer) readings. 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.

4.1.4、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`. Also, `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 states in time and uses sensed sensor data to correct the predicted estimates.

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

2) 、Topic

/	Topic Name	Type	Attributes
Subscribed	/imu/data	sensor_msgs/Imu	Filtered imu information
Subscribed	/odom_raw	nav_msgs/Odometry	Odometer Information
Published	/odom	nav_msgs/Odometry	Fusion odometer information
Published	/tf	tf2_msgs/TFMessage	Coordinate system information

3) 、Parameter

- frequency: The true frequency (in Hz) at which the filter produces state estimates. **Note: The filter will not start computing until at least one message has been received from one of the inputs.**
- [sensor] : For each sensor, the user needs to define this parameter according to the message type. Each parameter name is indexed from 0 (e.g. odom0, odom1, etc.) and must be defined in order (e.g. don't use pose0 and pose2 if pose1 is not already defined). The value of each parameter is the topic name for that sensor.

```
odom0: /odom_raw  
imu0: /imu/data
```

- [sensor]_differential: For each sensor message defined above that contains 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 taken at time t from the relevant sensor, we will first subtract the measurement at time t-1 and then convert the resulting value to velocity..

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

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

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

- two_d_mode: Set this to true if your robot operates in a flat environment and can ignore small changes in the ground (as reported by the IMU). It fuses all 3D variables (Z, roll, pitch and their respective velocity and acceleration) into a value of 0. This ensures that the covariances of these values don't explode, while ensuring that your robot's state estimate remains fixed in the X-Y plane.
- odom0_config: [false, false, false, false, false, false, true, true, false, false, false, true, false, false, false]

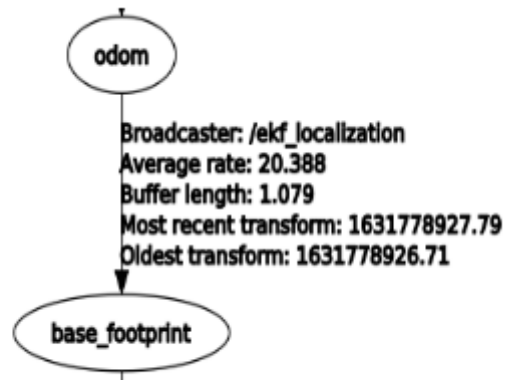
The order of Boolean values is: [[X],[Y],[Z],[roll],[pitch],[yaw],[X '],[Y '],[Z '],[roll '],[pitch '],[yaw '],[X "],[Y "],[Z "]]. The user must specify which variables of these messages should be fused into the final state estimate.

4) 、Published Transform

If the user's `world_frame` parameter is set to the value of `odom_frame`, the transformation is posted 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 transformation is 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 transformation 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
```



;