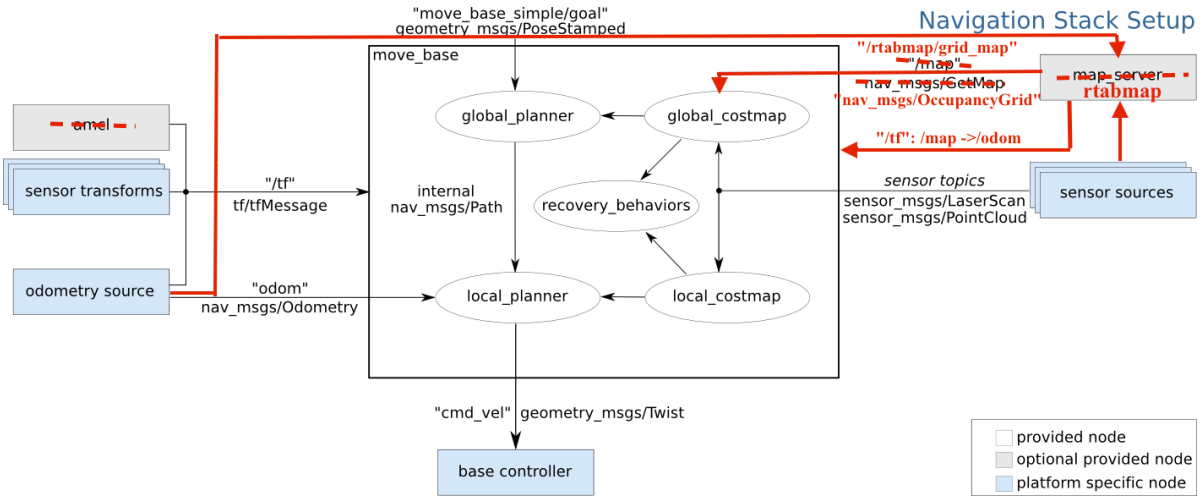
7. RTAB-Map 3D mapping navigation

wiki: http://wiki.ros.org/rtabmap_ros

7.1. Introduction

This package is a ROS function package for RTAB Map, an RGB-D SLAM method based on a global loop closure detector with real-time constraints. This package can be used to generate 3D point clouds of environments and create 2D occupancy raster maps for navigation.



As can be seen from the above figure, Monte Carlo positioning amcl is not required. RTAB Map has its own positioning function; if used, it will cause repeated positioning and positioning failure. When using RTAB Map to navigate the core framework, the initialized map is provided by RTAB Map, not map_server.

7.2. Map construction and use

Note: When building a map, the slower the speed, the better the effect (note that the rotation speed should be slower). If the speed is too fast, the effect will be poor.

According to different models, you only need to set the purchased model in [.bashrc], X1 (normal four-wheel drive) X3 (Mailun) Take X3 as an example

```
#Raspberry Pi 5 master needs to enter docker first, please perform this step
#If running the script into docker fails, please refer to ROS/07, Docker tutorial
~/run_docker.sh
```

Open the [.bashrc] file

```
sudo vim .bashrc
```

Find the [ROBOT_TYPE] parameters and modify the corresponding car model

```
export ROBOT_TYPE=X3 # ROBOT_TYPE: X1 X3 X3plus R2 X7
```

7.2.1. Start

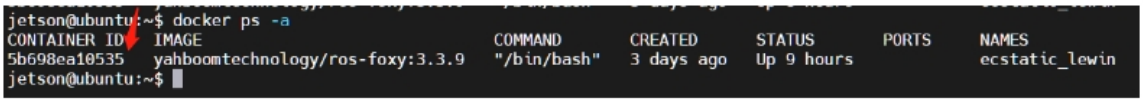
Start the underlying driver command (robot side)

```
roslaunch yahboomcar_nav laser_astrapro_bringup.launch
```

<PI5 needs to open another terminal to enter the same docker container

1. In the above steps, a docker container has been opened. You can open another terminal on the host (car) to view:

```
docker ps -a
```



2. Now enter the docker container in the newly opened terminal:

```
docker exec -it 5b698ea10535 /bin/bash
```

After successfully entering the container, you can open countless terminals to enter the container.

Command to start mapping or navigation (robot side)

```
roslaunch yahboomcar_nav yahboomcar_rtabmap.launch use_rviz:=False
```

- use_rviz parameter: whether to open rviz.

Start visualization (virtual machine)

```
roslaunch yahboomcar_nav view_rtabmap.launch
```

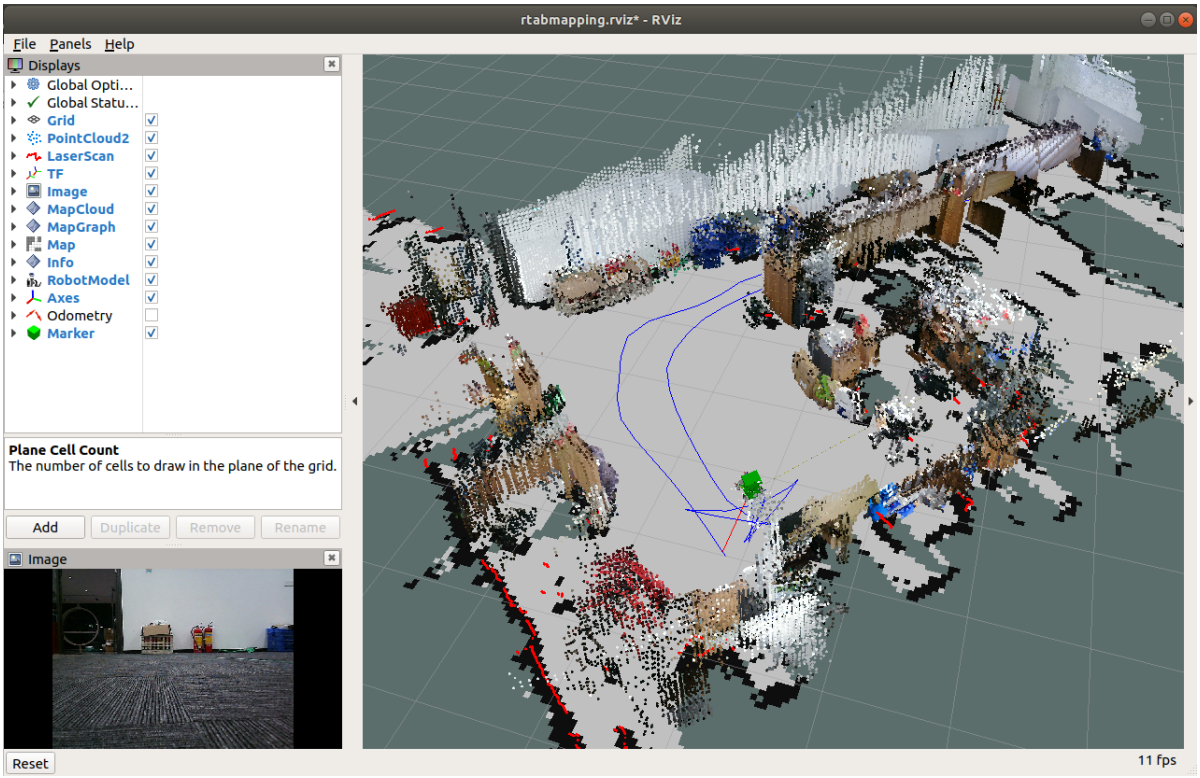
Keyboard control node (virtual machine)

```
rosrun teleop_twist_keyboard teleop_twist_keyboard.py # System integration
roslaunch yahboomcar_ctrl yahboom_keyboard.launch # yahboomcar customization
```

7.2.2. Map construction

After starting according to the above method, choose any method to control the mapping (handle control is recommended); the slower the speed when constructing the map, the better the effect (especially the angular speed); the robot will cover the area to be mapped and the map will be as closed as possible.

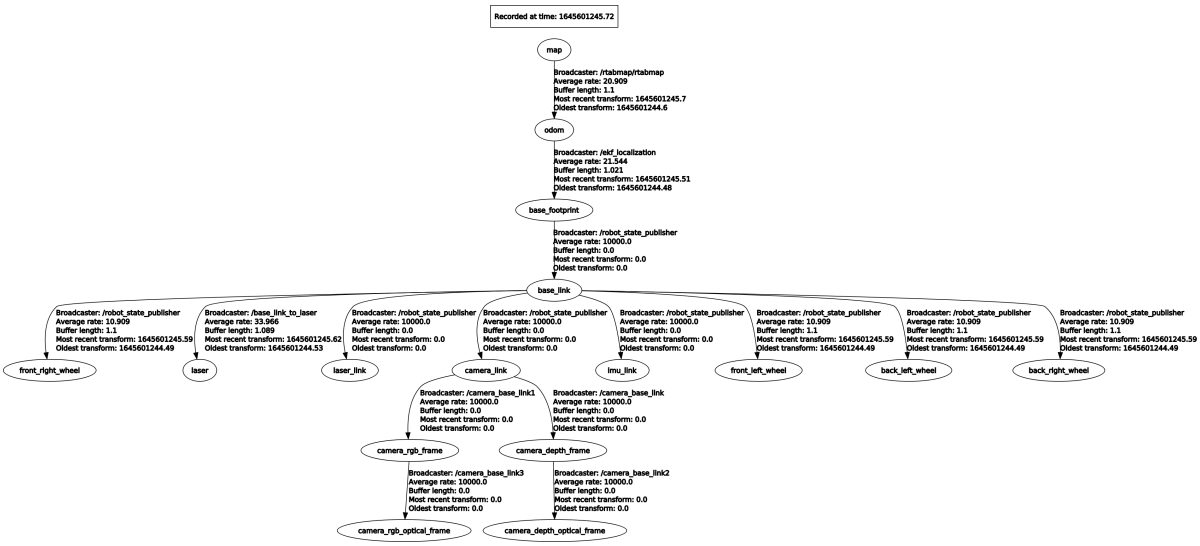
- Joystick control
- Keyboard control



When the map construction is completed, directly [ctrl+c] exit the map construction node, and the system will automatically save the map. The default saving path of the map is [~/.ros/rtabmap.db].

View tf tree

```
rosrun rqt_tf_tree rqt_tf_tree
```



Node view

```
rqt_graph
```

As can be seen from the above figure, the information that the [rtabmap] node needs to subscribe to: radar data, camera data, and tf data.

7.3. Navigation and obstacle avoidance

Note: [R2] on the remote control handle has the function of canceling the target point.

Start the underlying driver command (robot side)

```
roslaunch yahboomcar_nav laser_astrapro_bringup.launch
```

Command to start mapping or navigation (robot side)

```
roslaunch yahboomcar_nav yahboomcar_rtabmap_nav.launch use_rviz:=False
```

- use_rviz parameter: whether to open rviz.

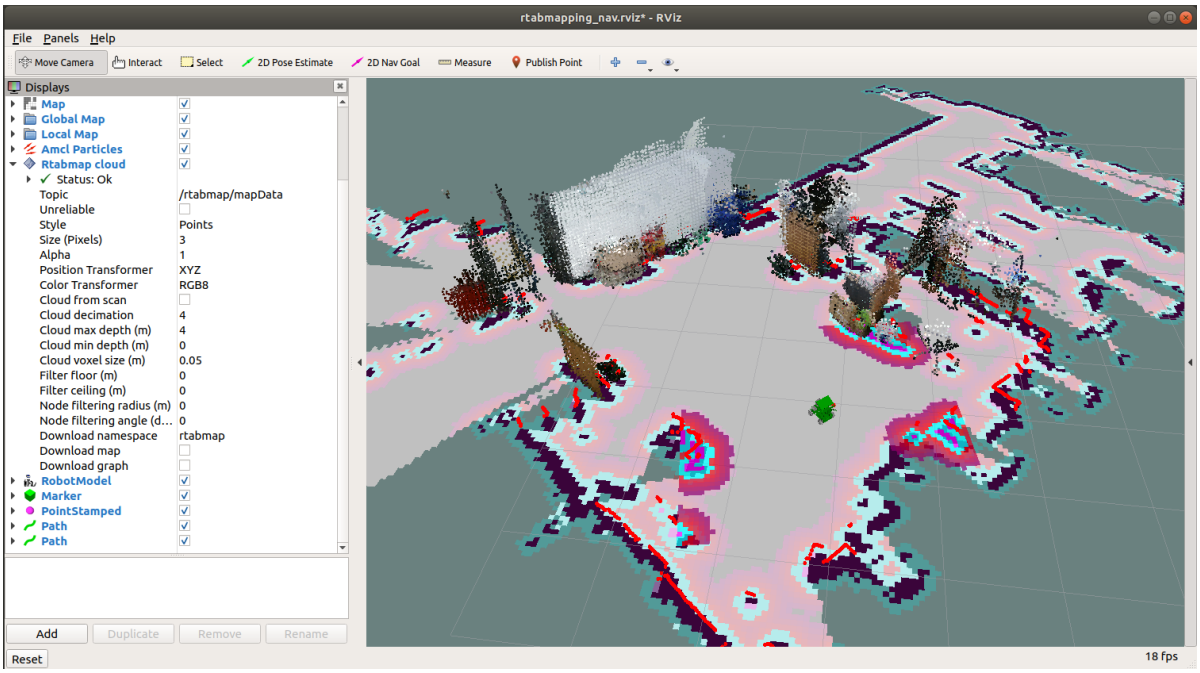
Start visualization (virtual machine)

```
roslaunch yahboomcar_nav view_rtabmap_nav.launch
```

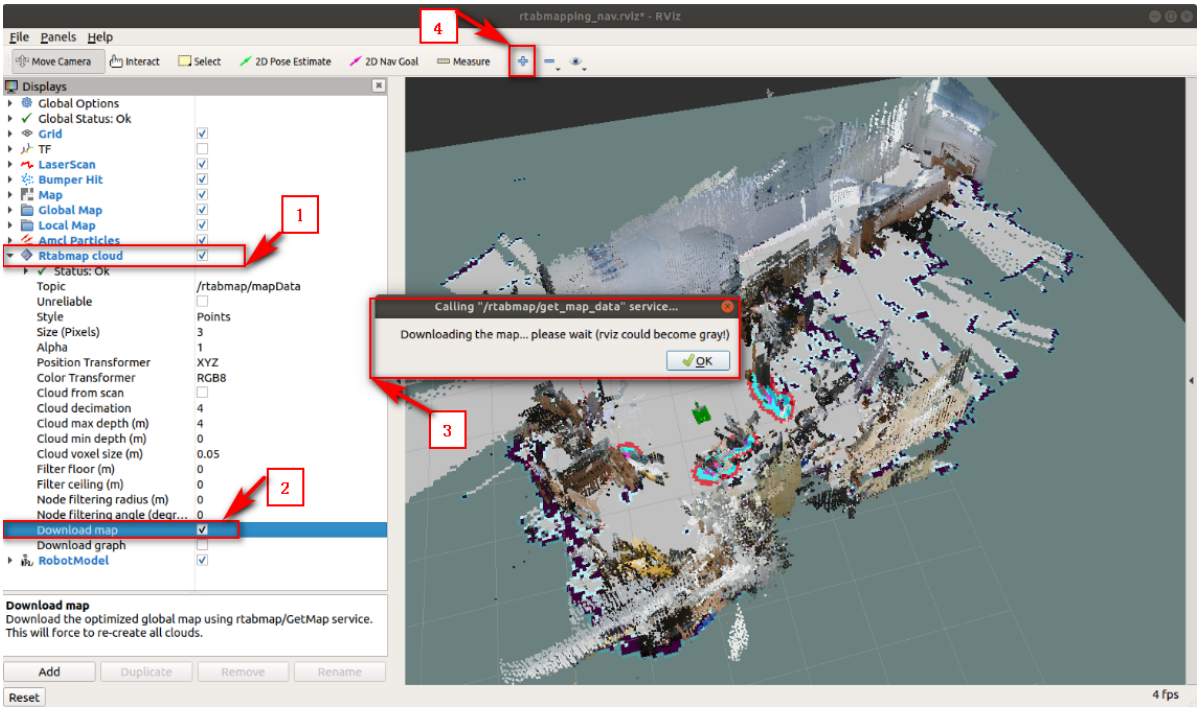
Keyboard control node (virtual machine)

```
rosrun teleop_twist_keyboard teleop_twist_keyboard.py # System integration
roslaunch yahboomcar_ctrl yahboom_keyboard.launch # yahboomcar customization
```

When the navigation mode is turned on, the system automatically loads the 2D raster map. It cannot directly load the 3D map and needs to be loaded manually.



Load the three-dimensional map (1, 2, 3), 4 is to add the rviz debugging tool.



At this time, you can manually add [MarkerArray] to facilitate multi-point navigation and observation, and adjust [rviz] display parameters according to needs, such as the size of lidar points.

7.3.1. Single-point navigation

- Use the [2D Pose Estimate] of the [rviz] tool to set the initial pose until the position of the car in the simulation is consistent with the position of the actual car.
- Click [2D Nav Goal] of the [rviz] tool, and then select a target point on the map where there are no obstacles. Release the mouse to start navigation. Only one target point can be selected, and it will stop when it is reached.

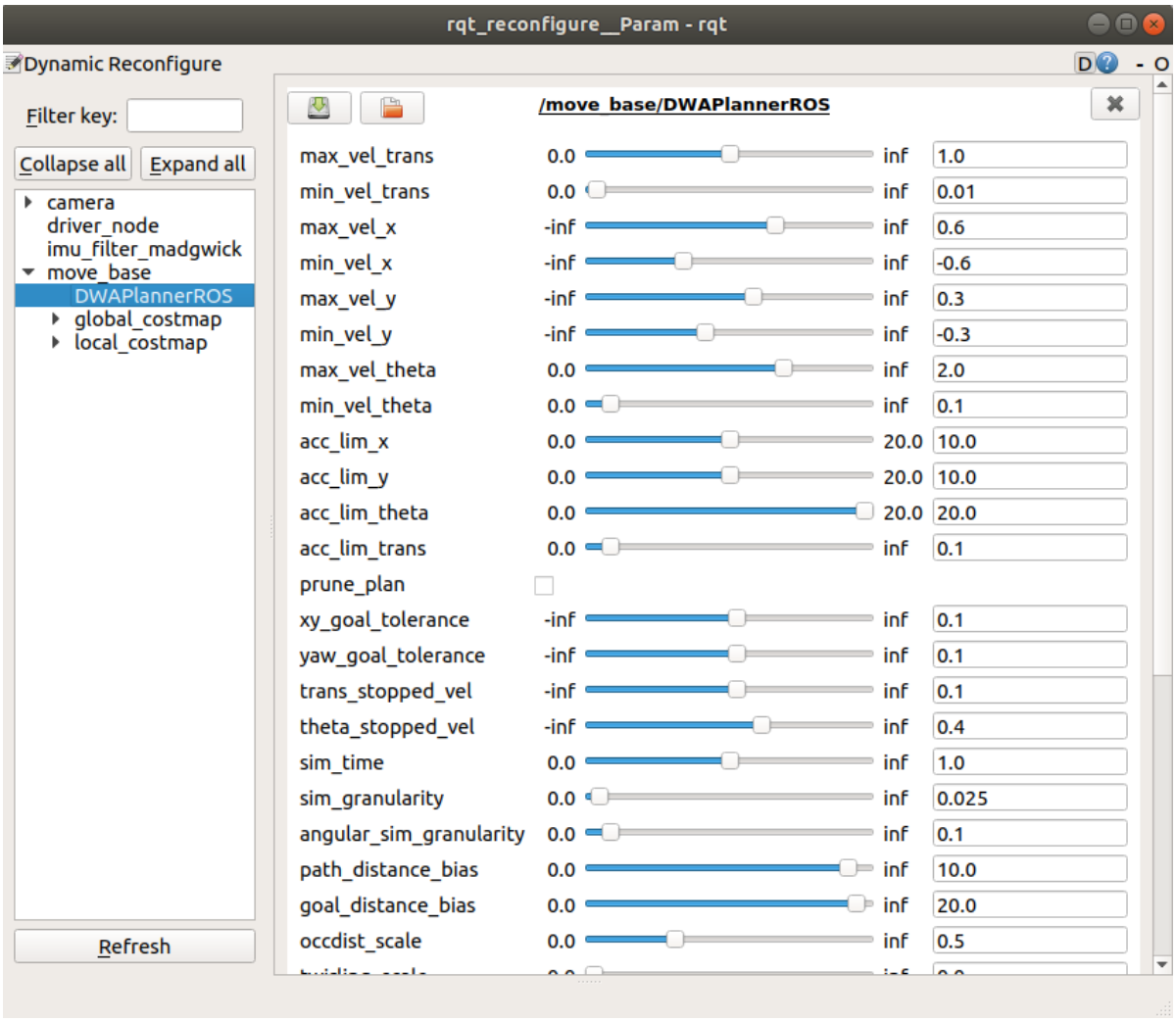
7.3.2. Multi-point navigation

- Same as the first step of single-point navigation, first set the initial pose of the car.
- Click [Publish Point] of the [rviz] tool, and then select the target point on the map where there are no obstacles. Release the mouse to start navigation. You can click [Publish Point] again, and then select the point, and the robot will click on it. Cruising between points.
- When using the [2D Pose Estimate] tool of the [rviz] tool to set the initial pose of the car, the multi-point navigation function is automatically canceled.

7.3.3. Parameter configuration

After starting the navigation function, open the dynamic parameter adjustment tool, adjust according to your own needs, and observe the robot's motion status until the effect is optimal. Record the current parameters and modify them to the corresponding dwa_local_planner_params.yaml file under the yahboomcar_nav function package.

```
rosrun rqt_reconfigure rqt_reconfigure
```



Looking at the yahboomcar_navigation.launch file, we can see that the navigation parameters are modified in the move_base.launch file under the yahboomcar_rtabmap_nav function package.

```
<launch>
     <!-- Whether to open rviz || Whether to open rviz -->
     <arg name="use_rviz" default="false"/>
     <!-- MarkerArray node-->
     <node name='send_mark' pkg="yahboomcar_nav" type="send_mark.py"/>
     <!-- Mobile APP node -->
     <include file="$(find yahboomcar_nav)/launch/library/app.launch"/>
     <!-- Navigation core component move_base -->
     <include file="$(find yahboomcar_nav)/launch/library/move_base.launch"/>
     <!-- rtabmap navigation -->
     <include file="$(find yahboomcar_nav)/launch/library/rtabmap_nav.launch"/>
     <!-- RVIZ -->
     <include file="$(find yahboomcar_nav)/launch/view/view_rtabmap_nav.launch"
if="$(arg use_rviz)"/>
</launch>
```

Find the move_base.launch file and open the example file as follows. It can be modified and replaced according to your needs. At this time, [DWA Planner] is selected and the [DWA] file is loaded.

```
<launch>
     <arg name="robot_type" value="$(env ROBOT_TYPE)" doc="robot_type
[X1,X3,X3plus,R2,X7]"/>
```

```
    <!-- Arguments -->
    <arg name="move_forward_only" default="false"/>
    <!-- move_base -->
    <node pkg="move_base" type="move_base" respawn="false" name="move_base"
output="screen">
        <rosparam file="$(find
yahboomcar_nav)/param/common/global_costmap_params.yaml" command="load"/>
        <rosparam file="$(find
yahboomcar_nav)/param/common/local_costmap_params.yaml" command="load"/>
        <rosparam file="$(find
yahboomcar_nav)/param/common/move_base_params.yaml" command="load"/>
        <rosparam file="$(find
yahboomcar_nav)/param/common/costmap_common_params_$(arg robot_type).yaml"
command="load"
            ns="global_costmap"/>
        <rosparam file="$(find
yahboomcar_nav)/param/common/costmap_common_params_$(arg robot_type).yaml"
command="load"
            ns="local_costmap"/>
        <rosparam file="$(find
yahboomcar_nav)/param/common/dwa_local_planner_params_$(arg robot_type).yaml"
command="load"/>
        <param name="base_local_planner" type="string"
value="dwa_local_planner/DWAPlannerROS" if="$(eval arg('robot_type') == 'X3')"/>
        <!-- <param name="base_local_planner" type="string"
value="teb_local_planner/TebLocalPlannerROS"/>--><param
name="DWAPlannerROS/min_vel_x" value="0.0" if="$(arg move_forward_only)"/>
        <remap from="cmd_vel" to="cmd_vel"/>
        <remap from="odom" to="odom"/>
    </node>
</launch>
```

Note: When using the DWA planner, the difference between an omnidirectional car and a differential car lies in whether the speed in the Y direction is 0. There are clear comments in it, which can be modified according to the actual situation.

Enter the dwa_local_planner_params.yaml file under the yahboomcar_nav function package. Some parameters are as follows:

```
DWAPlannerROS:
  # Robot Configuration Parameters
  # Absolute value of maximum linear velocity in x direction, unit:
meters/second
  # The maximum y velocity for the robot in m/s
  max_vel_x: 0.6
  # The absolute value of the minimum linear velocity in the x direction, a
negative number means it can be retreated, unit: meters/second
  # The minimum x velocity for the robot in m/s, negative for backwards motion.
  min_vel_x: -0.6
  # Absolute value of the maximum linear velocity in the y direction, unit:
meters/second. The differential robot is 0
  # The maximum y velocity for the robot in m/s
  max_vel_y: 0.3
  # The absolute value of the minimum linear velocity in the y direction, unit:
meters/second. The differential robot is 0
```

```
   # The minimum y velocity for the robot in m/s
   min_vel_y: -0.3
... ...
   #The ultimate acceleration of the robot in the x direction, the unit is
meters/sec^2
   # The x acceleration limit of the robot in meters/sec^2
   acc_lim_x: 10.0
   # The ultimate acceleration of the robot in the y direction, which is 0 for
differential robots
   # The y acceleration limit of the robot in meters/sec^2
   acc_lim_y: 10.0
... ..
```

Other parameter files can be opened, combined with comments and courseware, and modified according to your own needs.

7.4, node rtabmap

This is the master node for this package. It is a wrapper around the RTAB mapping core library. Here, when loop closure is detected, the map is incrementally built and optimized. The node's online output is this map, which contains the latest data added to the map. The default location of the RTAB map database is [.ros/rtabmap.db], and the workspace is also set to [.ros].

7.4.1. Subscribe to topics

Name	Type	Parse
odom	nav_msgs/Odometry	Odometry. If the parameter subscribe_depth or subscribe_stereo is true; and odom_frame_id is not set, this is a required parameter.
rgb/image	sensor_msgs/Image	RGB/monocular image.
rgb/camera_info	sensor_msgs/CameraInfo	RGB camera parameters.
depth/image	sensor_msgs/Image	Depth image.
scan	sensor_msgs/LaserScan	Single line laser.
scan_cloud	sensor_msgs/PointCloud2	Laser scanning point cloud stream.
left/image_rect	sensor_msgs/Image	Left eye correction image.
left/camera_info	sensor_msgs/CameraInfo	Left eye camera parameters.
right/image_rect	sensor_msgs/Image	Right eye correction image.
right/camera_info	sensor_msgs/CameraInfo	Right eye camera parameters.
goal	geometry_msgs/PoseStamped	Plan a path to achieve this goal using the current online map.
rgbd_image	rtabmap_ros/RGBDImage	RGB-D sync image, only if subscribe_rgbd is true.

7.4.2. Publishing topics

Name	Type	Parse
info	rtabmap_ros/Info	rtabmap information.
mapData	rtabmap_ros/MapData	rtabmap's graph and latest node data.
mapGraph	rtabmap_ros/MapGraph	rtabmap’s graph
grid_map	nav_msgs/OccupancyGrid	Map occupancy grid generated by laser scanning.
proj_map	nav_msgs/OccupancyGrid	Deprecated, use /grid_map instead of Grid/FromDepth=true
cloud_map	sensor_msgs/PointCloud2	A 3D point cloud generated from a local raster.
cloud_obstacles	sensor_msgs/PointCloud2	Generate a 3D point cloud of obstacles from a local mesh.
cloud_ground	sensor_msgs/PointCloud2	A 3D ground point cloud generated from a local raster.
scan_map	sensor_msgs/PointCloud2	3D point cloud generated by 2D scan or 3D scan.
labels	visualization_msgs/MarkerArray	Convenient way to display graph labels in RVIZ.
global_path	nav_msgs/Path	The planning pose of the global path. Published only once per planned path.
local_path	nav_msgs/Path	Plan the future local pose corresponding to the global path. Published every time the map is updated.
goal_reached	std_msgs/Bool	Plan status message whether the goal was successfully achieved.
goal_out	geometry_msgs/PoseStamped	Plan the current metric goal sent from rtabmap's topology planner. For example, you can connect to move_base via move_base_simple/goal.
octomap_full	octomap_msgs/Octomap	Get octomap. Only available if rtabmap_ros is built with octomap.

Name	Type	Parse
octomap_binary	octomap_msgs/Octomap	Get octomap. Only available if rtabmap_ros is built with octomap.
octomap_occupied_space	sensor_msgs/PointCloud2	Point cloud of octomap occupied space (obstacles and ground). Only available if rtabmap_ros is built with octomap.
octomap_obstacles	sensor_msgs/PointCloud2	Point cloud of obstacles on octomap. Only available if rtabmap_ros is built with octomap.
octomap_ground	sensor_msgs/PointCloud2	Point cloud of octomap. Only available if rtabmap_ros is built with octomap.
octomap_empty_space	sensor_msgs/PointCloud2	The empty point cloud of octomap. Only available if rtabmap_ros is built with octomap.
octomap_grid	nav_msgs/OccupancyGrid	Project an octomap into a 2D occupancy grid map. Only available if rtabmap_ros is built with octomap.

7.4.3, Service

Name	Type	Parse
get_map	rtabmap_ros/GetMap	Call this service to get a standard 2D occupancy grid.
get_map_data	rtabmap_ros/GetMap	Call this service to get map data.
publish_map	rtabmap_ros/PublishMap	Call this service to publish map data.
list_labels	rtabmap_ros/ListLabels	Get the current labels of the graph.
update_parameters	std_srvs/Empty	The node will be updated with the current parameters of the rosparam server.
reset	std_srvs/Empty	Delete the map.
pause	std_srvs/Empty	Pause mapping.
resume	std_srvs/Empty	Resume mapping.

Name	Type	Parse
trigger_new_map	std_srvs/Empty	Will start a new map.
backup	std_srvs/Empty	Back up the database to "database_path.back" (default ~/.ros/rtabmap.db.back).
set_mode_localization	std_srvs/Empty	Set pure localization mode.
set_mode_mapping	std_srvs/Empty	Set mapping mode.
set_label	rtabmap_ros/SetLabel	Set the label to the latest node or the specified node.
set_goal	rtabmap_ros/SetGoal	Plan and set topology goals.
octomap_full	octomap_msgs/GetOctomap	Get octomap. Only available when rtabmap_ros is built with octomap
octomap_binary	octomap_msgs/GetOctomap	Get octomap. Only available when rtabmap_ros is built with octomap

7.4.4. Parameters

name	type	default value	parse
subscribe_depth	bool	true	Subscribe to depth image
subscribe_scan	bool	false	Subscribe to lidar data
subscribe_scan_cloud	bool	false	Subscribe to laser 3D point cloud
subscribe_stereo	bool	false	Subscribe to stereo images
subscribe_rgbd	bool	false	Subscribe to rgbd_image topic
frame_id	string	base_link	The frame to connect to the mobile base.
map_frame_id	string	map	The coordinate system attached to the map.
odom_frame_id	string	‘’	The coordinate system attached to the odometer.
odom_tf_linear_variance	double	0.001	When using odom_frame_id, the first 3 values of the diagonal of the 6x6 covariance matrix are set to this value.

name	type	default value	parse
odom_tf_angular_variance	double	0.001	When using odom_frame_id, the last 3 values of the 6x6 covariance matrix diagonal are set to this value
queue_size	int	10	Message queue size per synchronization topic.
publish_tf	bool	true	Publish TF from /map to /odom.
tf_delay	double	0.05	
tf_prefix	string	‘ ’	The prefix to be added to the generated tf.
wait_for_transform	bool	true	The wait for the transform while the tf transform is still unavailable (the maximum wait time for the transform is seconds).
wait_for_transform_duration	double	0.1	The waiting time of wait_for_transform.
config_path	string	‘ ’	Path to the configuration file containing RTAB mapping parameters. Parameters set in the startup file will override parameters in the configuration file.
database_path	string	.ros/rtabmap.db	The path of the rtabmap database.
gen_scan	bool	false	Generate a laser scan from a depth image (using the middle horizontal line of the depth image). Not generated if subscribe_scan or subscribe_scan_cloud is true.
gen_scan_max_depth	double	4.0	The maximum depth of the generated laser scan.

name	type	default value	parse
approx_sync	bool	false	Synchronize using the approximate time of the input message. If false, note that the odometry input must have exactly the same timestamp as the input image
rgbd_cameras	int	1	Number of RGB-D cameras to use (when subscribe_rgbd is true). Currently, up to 4 cameras can be synced simultaneously.
use_action_for_goal	bool	false	use actionlib sends the metric target to move_base.
odom_sensor_sync	bool	false	Adjust the image and scan pose relative to the odometry pose for each node added to the graph.
gen_depth	bool	false	Generate a depth image from the scanned cloud projection to the RGB camera, taking into account the displacement of the RGB camera based on odometry and lidar frames.
gen_depth_decimation	int	1	Reduce the image size of the received camera information (create a smaller depth image)
gen_depth_fill_holes_size	int	0	Fill empty pixels to this size. Interpolates values from adjacent depth values. 0 means disabled.
gen_depth_fill_iterations	double	0.1	Maximum depth error to interpolate (m).
gen_depth_fill_holes_error	int	1	Number of iterations to fill holes.
map_filter_radius	double	0.0	Load data for only one node in the filter radius (using the latest data) up to the filter angle (map filter angle).

name	type	default value	parse
map_filter_angle	double	30.0	The angle to use when filtering nodes before creating the map. Reference map_filter_radius
map_cleanup	bool	true	If there are no map cloud maps, raster maps, or project maps subscribed to, clear the corresponding data.
latch	bool	true	If true, the last message posted on the map topic will be saved.
map_always_update	bool	true	Always update the occupancy raster map
map_empty_ray_tracing	bool	true	Perform ray tracing to fill the unknown space of invalid 2D scan rays (assuming invalid rays are infinite). Only used if map_always_update is also true.

7.4.5, tf conversion

what is needed:

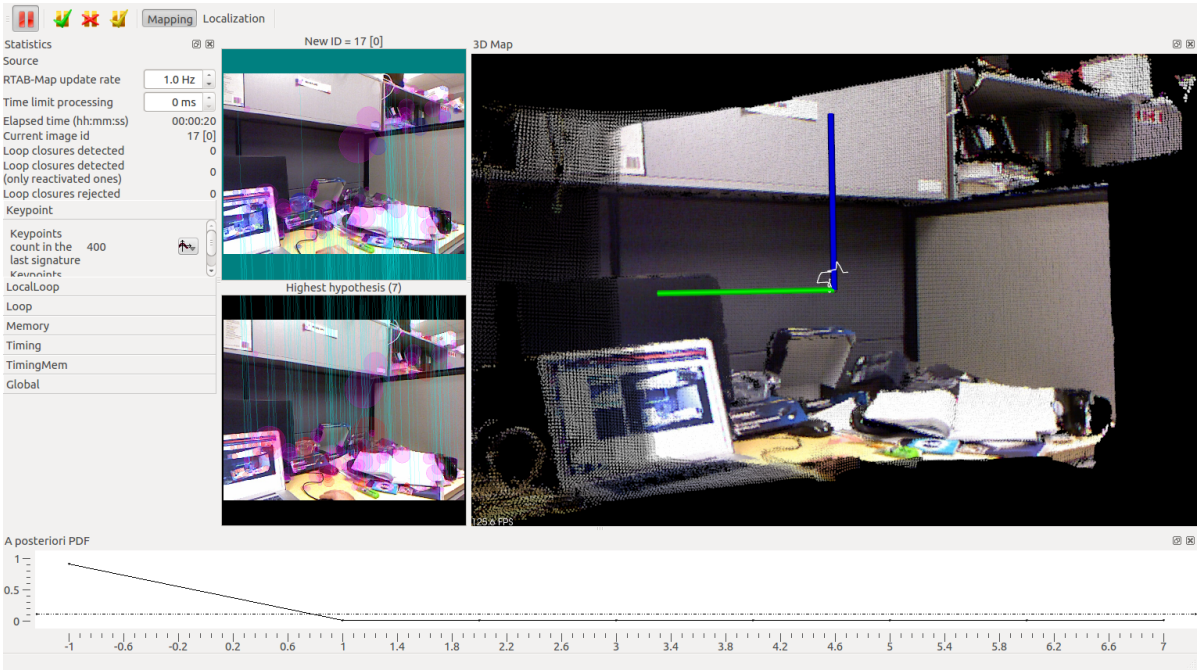
- base_link → sensor
- odom → base_link

which provided:

map → odom

7.5, node rtabmapviz

This node starts the visual interface of RTAB-Map. It is a wrapper for the RTAB-MapGUI library. Its purpose is the same as rviz, but with specific options for RTAB-Map.



7.5.1. Subscribe to topics

Name	Type	Parse
odom	nav_msgs/Odometry	Odometry. Required if the parameters subscribe_depth or subscribe_stereo are true and odom_frame_id is not set.
rgb/image	sensor_msgs/Image	RGB/monocular image. If the parameter subscribe_stereo is true, this option is not required (left/image_rect is used instead).
rgb/camera_info	sensor_msgs/CameraInfo	RGB camera metadata. If the parameter subscribe_stereo is true, this option is not required (left/camera_info is used instead).
depth/image	sensor_msgs/Image	Register depth image. Required if parameter subscribe_depth is true.
scan	sensor_msgs/LaserScan	Laser scan stream. Required if parameter subscribe_scan is true.
scan_cloud	sensor_msgs/PointCloud2	Laser scan stream. Required if parameter subscribe_scan_cloud is true.
left/image_rect	sensor_msgs/Image	Left eye correction image. Required if parameter subscribe_stereo is true.
left/camera_info	sensor_msgs/CameraInfo	Left eye camera parameters. Required if parameter subscribe_stereo is true.
right/image_rect	sensor_msgs/Image	Right corrected image. Required if parameter subscribe_stereo is true.

Name	Type	Parse
right/camera_info	sensor_msgs/CameraInfo	Right eye camera parameters. Required if parameter subscribe_stereo is true.
odom_info	rtabmap_ros/OdomInfo	Required if the parameter subscribe_odom_info is true.
info	rtabmap_ros/Info	Statistical information of rtabmap.
mapData	rtabmap_ros/MapData	rtabmap's chart and latest node data.
rgbd_image	rtabmap_ros/RGBDImage	RGB-D synchronized image, only when subscribe_rgbd is true.

7.5.2. Parameter configuration

name	type	default value	parse
subscribe_depth	bool	false	Subscribe to depth image
subscribe_scan	bool	false	Subscribe to lidar data
subscribe_scan_cloud	bool	false	Subscribe to the laser scanning point cloud.
subscribe_stereo	bool	false	Subscribe to stereo images.
subscribe_odom_info	bool	false	Subscribe to odom information messages.
subscribe_rgbd	bool	false	Subscribe to rgbd_image topic.
frame_id	string	base_link	The coordinate system connected to the mobile base.
odom_frame_id	string	‘’	The coordinate system of the odometer. If empty, rtabmapviz will subscribe to the odom topic to get odometry. If set, gets the odometer from tf.
tf_prefix	string	‘’	The prefix to be added to the generated tf.
wait_for_transform	bool	false	Wait for a transform (up to 1 second) when the tf transform is still not available.
queue_size	int	10	Message queue size per synchronization topic.
rgbd_cameras	int	1	Number of RGB-D cameras to use (when subscribe_rgbd is true). Currently, up to 4 cameras can be synced simultaneously.

7.5.3. Required tf conversion

- base_link → sensor coordinate system
- odom → base_link
- map → odom