6、Lidar mapping

Gmapping：http://wiki.ros.org/gmapping/

hector_slam：http://wiki.ros.org/hector_slam

hector_slam/Tutorials：http://wiki.ros.org/hector_slam/Tutorials/SettingUpForYourRobot

hector_mapping：http://wiki.ros.org/hector_mapping

karto：http://wiki.ros.org/slam_karto

Cartographer：https://google-cartographer.readthedocs.io/en/latest/

Cartographer ROS：https://google-cartographer-ros.readthedocs.io/en/latest/

rrt_exploration：http://wiki.ros.org/rrt_exploration

rrt_exploration/Tutorials：http://wiki.ros.org/rrt_exploration/Tutorials

map_server：https://wiki.ros.org/map_server

6.1、Instructions

6.1.1、Mapping

Note: When building a map, the slower the speed of the car, the better the effect (especially the rotation speed). If the speed is too fast, the effect will be poor.

Start command (note: the navigation effect of depth mapping alone is not good, so it is not recommended).

```
roslaunch transbot_nav usbcam_bringup.launch    # mono + laser + Transbot
roslaunch transbot_nav astra_bringup.launch     # Astra + Transbot
roslaunch transbot_nav laser_bringup.launch     # laser + Transbot
roslaunch transbot_nav transbot_bringup.launch  # Astra + laser + Transbot
```

Mapping

```
roslaunch transbot_nav transbot_map.launch map_type:=gmapping
roslaunch transbot_nav transbot_map.launch map_type:=hector
roslaunch transbot_nav transbot_map.launch map_type:=karto
roslaunch transbot_nav transbot_map.launch map_type:=cartographer
roslaunch transbot_nav rrt_exploration.launch
```

- Parameter 【map_type】: mapping algorithm 【gmapping,hector,karto,cartographer】, the default is 【gmapping】.

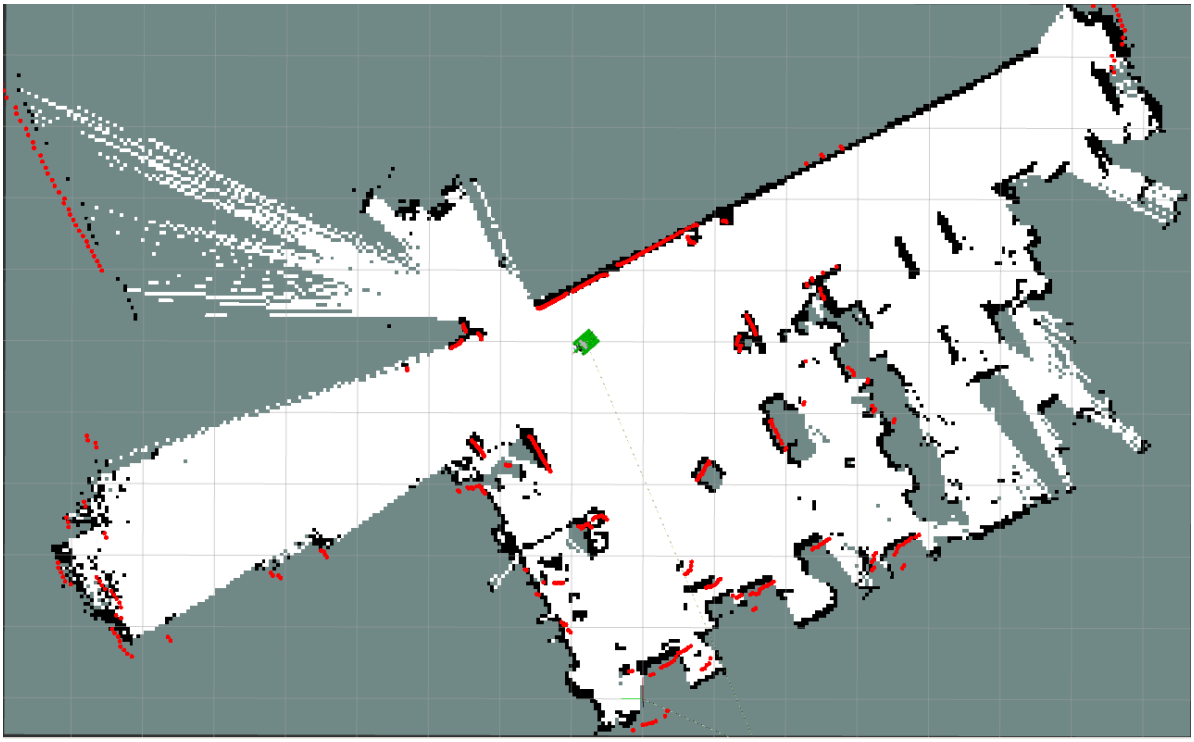
6.1.2、Usage

Run following command, then you can control robot movement by keyboard

```
rosrun teleop_twist_keyboard teleop_twist_keyboard.py  # system integration
roslaunch transbot_ctrl transbot_keyboard.launch       # customize
```

Or you can control robot by handle, no need run any code. The command for mapping or navigation includes the start command for the handle control.

We need to make sure that the robot walks all over the area to be mapped.
As shown below, the map should be closed.



There may be some scattered points during the mapping process. If the mapping environment is well closed, relatively regular, and the movement speed is slower, the scattering phenomenon will be much smaller.

6.1.3、Save map

There are different ways of saving maps in several mapping algorithms.

- cartographer：execute the following command

  ```
  bash ~/transbot_ws/src/transbot_nav/maps/carto_map.sh
  ```

- rrt_exploration：After selecting five points as required, the robot begins to explore and build maps.
  After the map is created, the system will automatically save the map and return to the zero point.
  The map is saved to this path: ~/transbot_ws/src/transbot_nav/maps/my_map，file name is rrt_map.
- gmapping,hector,karto：execute the following command to save file

```
rosrun map_server map_saver -f ~/transbot_ws/src/transbot_nav/maps/my_map    #
Method 1
bash ~/transbot_ws/src/transbot_nav/maps/map.sh                              #
Method 2
```

The map is saved to this path: ~/transbot_ws/src/transbot_nav/maps/，a pgm picture file and a yaml file.

map.yaml

```
image: map.pgm
resolution: 0.05
origin: [-15.4,-12.2,0.0]
negate: 0
occupied_thresh: 0.65
free_thresh:  0.196
```

Parameter analysis:

- image: The path of the map file, which can be an absolute path or a relative path.
- resolution: the resolution of the map, m/pixel
- origin: The 2D pose (x,y,yaw) in the lower left corner of the map, where yaw is rotated counterclockwise (yaw=0 means no rotation). Many parts of the current system ignore the yaw value.
- negate: whether to reverse the meaning of white/black and free/occupied (the interpretation of the threshold is not affected)
- Occupied_thresh: Pixels with occupation probability greater than this threshold will be considered as fully occupied.
- free_thresh: Pixels whose occupancy probability is less than this threshold will be considered completely free.

6.1.4、View info

View tf tree

```
rosrun rqt_tf_tree rqt_tf_tree
```

View node

```
rqt_graph
```

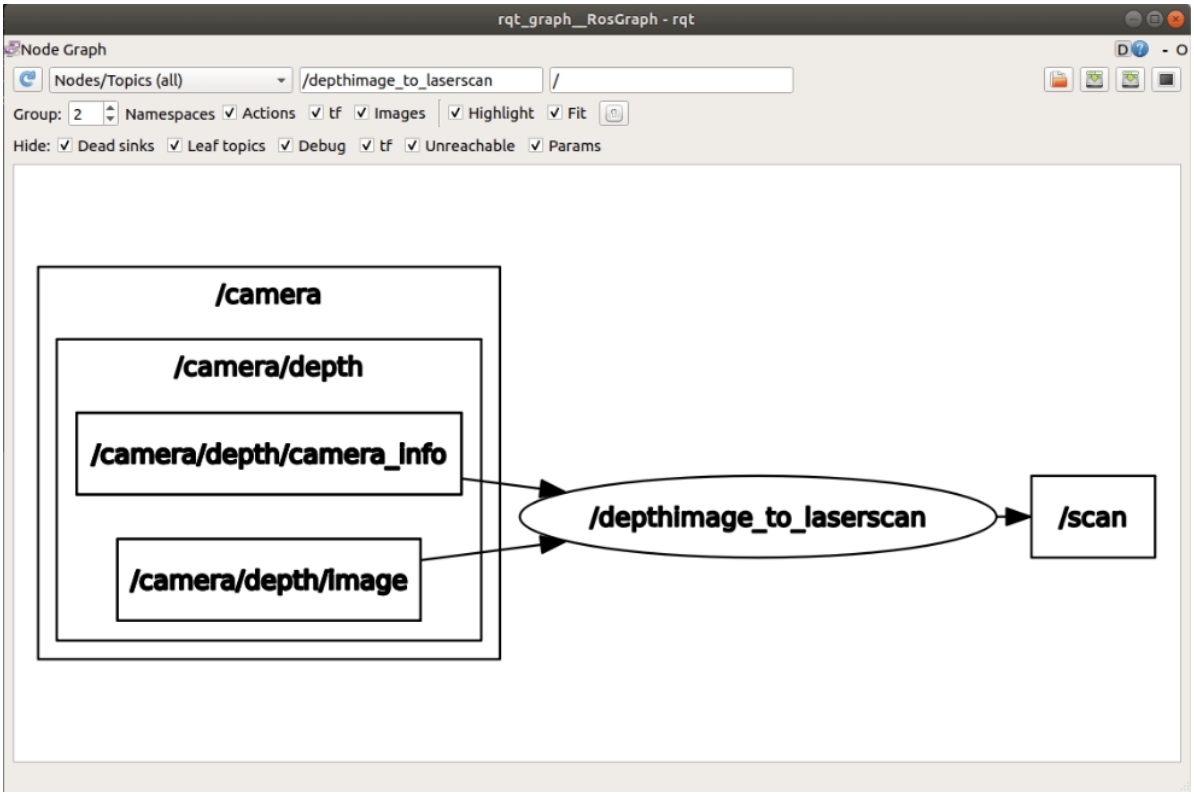
6.1.5、2D mapping by depth mapping alone

Start the driver reference【6.1.1】# Astra + Transbot; the command for starting the map is the same as【6.1.1】.

The function package depthimage_to_laserscan is mainly used to convert the depth image into lidar data. Its mapping function is the same as that of lidar.

Note: The scanning range of the depth camera is not 360°.

```
rqt_graph
```



6.2、Mapping algorithm

6.2.1、gmapping

1) Introduction

- Gmapping is a commonly used open source SLAM algorithm based on the filtering SLAM framework.
- Gmapping is based on the RBpf particle filter algorithm, which separates the positioning and mapping process, and performs positioning before mapping.
- Gmapping has made two major improvements to the RBpf algorithm: improved proposal distribution and selective resampling.

Advantages: Gmapping can construct indoor maps in real time, and the amount of calculation required to construct small scene maps is small and the accuracy is high.

Disadvantages: Not suitable for building large scene maps.

2) Topics and services

Subscribe to topics	Type	Description
tf	tf/tfMessage	Used for conversion between lidar coordinate system, base coordinate system and odometer coordinate system
scan	sensor_msgs/LaserScan	Lidar scan data
Topic	**Type**	**Description**
map_metadata	nav_msgs/MapMetaData	Publish map Meta data
map	nav_msgs/OccupancyGrid	Publish map raster data
~entropy	std_msgs/Float64	Release the estimation of robot pose distribution entropy
Service	**Type**	**Description**
dynamic_map	nav_msgs/GetMap	Get map data

3) Configuration parameter

Parameter	Type	Defaults value	Description
~throttle_scans	int	1	Process 1 out of every this many scans (set it to a higher number to skip more scans)
~base_frame	string	"base_link"	The frame attached to the mobile base.
~map_frame	string	"map"	The frame attached to the map.
~odom_frame	string	"odom"	The frame attached to the odometry system.
~map_update_interval	float	5.0	How long (in seconds) between updates to the map. Lowering this number updates the occupancy grid more often, at the expense of greater computational load.
~maxUrange	float	80.0	The maximum usable range of the laser. A beam is cropped to this value.
~sigma	float	0.05	The sigma used by the greedy endpoint matching
~kernelSize	int	1	The kernel in which to look for a correspondence
~lstep	float	0.05	The optimization step in translation
~astep	float	0.05	The optimization step in rotation
~iterations	int	5	The number of iterations of the scanmatcher
~lsigma	float	0.075	The sigma of a beam used for likelihood computation
~ogain	float	3.0	Gain to be used while evaluating the likelihood, for smoothing the resampling effects
~lskip	int	0	Number of beams to skip in each scan.

Parameter	Type	Defaults value	Description
~minimumScore	float	0	Minimum score for considering the outcome of the scan matching good. Can avoid jumping pose estimates in large open spaces when using laser scanners with limited range (e.g. 5m). Scores go up to 600+, try 50 for example when experiencing jumping estimate issues.
~srr	float	0.1	Odometry error in translation as a function of translation (rho/rho)
~srt	float	0.2	Odometry error in translation as a function of rotation (rho/theta)
~str	float	0.1	Odometry error in rotation as a function of translation (theta/rho)
~stt	float	0.2	Odometry error in rotation as a function of rotation (theta/theta)
~linearUpdate	float	1.0	Process a scan each time the robot translates this far
~angularUpdate	float	0.5	Process a scan each time the robot rotates this far
~temporalUpdate	float	-1.0	Process a scan if the last scan processed is older than the update time in seconds. A value less than zero will turn time based updates off.
~resampleThreshold	float	0.5	The Neff based resampling threshold
~particles	int	30	Number of particles in the filter
~xmin	float	-100.0	Initial minimum size of the map in x direction
~ymin	float	-100.0	Initial minimum size of the map in y direction
~xmax	float	100.0	Initial maximum size of the map in x direction
~ymax	float	100.0	Initial maximum size of the map in y direction
~delta	float	0.05	Resolution of the map (in metres per occupancy grid block)

Parameter	Type	Defaults value	Description
~llsamplerange	float	0.01	Translational sampling range for the likelihood
~llsamplestep	float	0.01	Translational sampling step for the likelihood
~lasamplerange	float	0.005	Angular sampling range for the likelihood
~lasamplestep	float	0.005	Angular sampling step for the likelihood
~transform_publish_period	float	0.05	How long (in seconds) between transform publications.
~occ_threh	float	0.25	Threshold on gmapping's occupancy values
~maxRange(float)	float	-	Threshold on gmapping's occupancy values

4）TF Transforms

Required tf Transforms TF	Description
laser-->base_link	sually a fixed value, broadcast periodically by a robot_state_publisher, or a `tf` static_transform_publisher.
base_link-->odom	usually provided by the odometry system (e.g., the driver for the mobile base)
Provided tf Transforms	**Description**
map-->odom	the current estimate of the robot's pose within the map frame

6.2.2、hector

1）Introduction

Features: hector_slam does not need to subscribe to the odometer/odom message, uses the Gauss Newton method, and directly uses the lidar to estimate the odometer information. However, when the robot speed is faster, it will cause deviations in the mapping effect, and the requirements for sensors are high.

When building maps, adjust the rotation speed of the trolley as low as possible.

There is no way to use the odom coordinate system, which is taken from the Wiki.

2. Use without odom frame

If you do not require the use of a odom frame (for example because your platform does not provide any usable odometry) you can directly publish a transformation from map to base_link:

```
    <param name="pub_map_odom_transform" value="true"/>
    <param name="map_frame" value="map" />
    <param name="base_frame" value="base_frame" />
    <param name="odom_frame" value="base_frame" />
```

2) Topics and services

Topic subscription	Type	Description
scan	sensor_msgs/LaserScan	The laser scan used by the SLAM system.
syscommand	std_msgs/String	System command. If the string equals "reset" the map and robot pose are reset to their inital state.
Published Topics	**Type**	**Description**
map_metadata	nav_msgs/MapMetaData	Get the map data from this topic
map	nav_msgs/OccupancyGrid	Get the map data from this topic
slam_out_pose	geometry_msgs/PoseStamped	The estimated robot pose without covariance
poseupdate	geometry_msgs /PoseWithCovarianceStamped	The estimated robot pose with an gaussian estimate of uncertainty
Services	**Type**	**Description**
dynamic_map	nav_msgs/GetMap	Call this service to get the map data.
reset_map	std_srvs/Trigger	Call this service to reset the map, and hector will start a whole new map from scratch. Notice that this doesn't restart the robot's pose, and it will restart from the last recorded pose.
pause_mapping	std_srvs/SetBool	Call this service to stop/start processing laser scans.

Topic subscription	Type	Description
restart_mapping_with_new_pose	hector_mapping/ResetMapping	Call this service to reset the map, the robot's pose, and resume mapping (if paused)

3) Parameters

Parameters	Type	Defaults value	Description
~base_frame	String	"base_link"	The name of the base frame of the robot. This is the frame used for localization and for transformation of laser scan data.
~map_frame	String	"map"	The name of the map frame.
~odom_frame	string	"odom"	The name of the odom frame.
~map_resolution	Double	0.025(m)	The map resolution [m]. This is the length of a grid cell edge.
~map_size	Int	1024	The size of the map.
~map_start_x	double	0.5	Location of the origin [0.0, 1.0] of the /map frame on the x axis relative to the grid map. 0.5 is in the middle.
~map_start_y	double	0.5	Location of the origin [0.0, 1.0] of the /map frame on the y axis relative to the grid map. 0.5 is in the middle.
~map_update_distance_thresh	double	0.4(m)	Threshold for performing map updates [m]. The platform has to travel this far in meters or experience an angular change as described by the map_update_angle_thresh parameter since the last update before a map update happens.
~map_update_angle_thresh	double	0.9(rad)	Threshold for performing map updates [rad]. The platform has to experience an angular change as described by this parameter of travel as far as specified by the map_update_distance_thresh parameter since the last update before a map update happens.
~map_pub_period	double	2.0	The map publish period [s].
~map_multi_res_levels	int	3	The number of map multi-resolution grid levels.
~update_factor_free	double	0.4	The map update modifier for updates of free cells in the range [0.0, 1.0].
~update_factor_occupied	double	0.9	The map update modifier for updates of occupied cells in the range [0.0, 1.0].
~laser_min_dist	double	0.4(m)	The minimum distance [m] for laser scan endpoints to be used by the system.
~laser_max_dist	double	30.0(m)	The maximum distance [m] for laser scan endpoints to be used by the system
~laser_z_min_value	double	-1.0(m)	The minimum height [m] relative to the laser scanner frame for laser scan endpoints to be used by the system.
~laser_z_max_value	double	1.0(m)	The maximum height [m] relative to the laser scanner frame for laser scan endpoints to be used by the system.

Parameters	Type	Defaults value	Description
~pub_map_odom_transform	bool	true	Determine if the map->odom transform should be published by the system.
~output_timing	bool	false	Output timing information for processing of every laser scan via ROS_INFO.
~scan_subscrible_queue_size	int	5	The queue size of the scan subscriber.
~pub_map_scanmatch_transform	bool	true	Determines if the scanmatcher to map transform should be published to tf.
~tf_map_scanmatch_transform_frame_name	String	"scanmatcher_frame"	The frame name when publishing the scanmatcher to map transform as described in the preceding parameter.

4) TF Transforms

Required tf Transforms	Description
laser-->base_link	usually a fixed value, broadcast periodically by a robot_state_publisher, or a `tf` static_transform_publisher.
Provided tf Transforms	**Description**
map-->odom	the current estimate of the robot's pose within the map frame (only provided if parameter "pub_map_odom_transform" is true).

6.2.3、karto

1) Introduction

Karto is a 2D laser SLAM solution, which is based on a sparse graph optimization method with closed loop detection. Karto uses the spa (karto_slam) or g2o (nav2d) optimization library, and the front-end and back-end uses a single-threaded process. It uses odom to predict the initial position.

2) Topics and Services

Subscribed Topics	Type	Description
scan	sensor_msgs/LaserScan	Transforms necessary to relate frames for laser, base, and odometry
tf	tf/tfMessage	Laser scans to create the map from
Published Topics	**Type**	**Description**
map_metadata	nav_msgs/MapMetaData	Get the metadata of the map data (resolution, width, height, ...)
map	nav_msgs/OccupancyGrid	Get the map data from this topic, which is latched, and updated periodically
visualization_marker_array	visualisation_msgs / MarkerArray	Get the pose graph from this topic, which is updated periodically
Published Topics	**Type**	**Description**
dynamic_map	nav_msgs/GetMap	Call this service to get the map data

3) Parameters

- General parameters

Parameters	Type	Defaults value	Description
~base_frame	string	"base_link"	The frame attached to the mobile base.
~map_frame	string	"map"	The frame attached to the map.
~odom_frame	string	"odom"	The frame attached to the odometry system.
~throttle_scans	int	1	Process 1 out of every this many scans (set it to a higher number to skip more scans)
~map_update_interval	float	5.0	How long (in seconds) between updates to the map. Lowering this number updates the occupancy grid more often, at the expense of greater computational load.
~resolution	float	0.05	Resolution of the map (in metres per occupancy grid block)
~delta	float	0.05	Resolution of the map (in metres per occupancy grid block). Same as resolution. Defined for compatibility with the parameter names of gmapping.
~transform_publish_period	float	0.05	How long (in seconds) between transform publications. To disable broadcasting transforms, set to `0`.
use_scan_matching	bool	true	When set to true, the mapper will use a scan matching algorithm. In most real-world situations this should be set to true so that the mapper algorithm can correct for noise and errors in odometry and scan data. In some simulator environments where the simulated scan and odometry data are very accurate, the scan matching algorithm can produce worse results. In those cases set this to false to improve results.
use_scan_barycenter	bool	true	Use the barycenter of scan endpoints to define distances between scans.
minimum_travel_distance	double	0.2	Sets the minimum travel between scans.
minimum_travel_heading	double	deg2rad(10)=0.087266461	Sets the minimum heading change between scans
scan_buffer_size	int	70	Sets the length of the scan chain stored for scan matching. scan_buffer_size should be set to approximately scan_buffer_maximum_scan_distance / minimum_travel_distance.
scan_buffer_maximum_scan_distance	double	20.0	Sets the maximum distance between the first and last scans in the scan chain stored for matching.
link_match_minimum_response_fine	double	0.8	Scans are linked only if the correlation response value is greater than this value.
link_scan_minimum_distance	double	10.0	Sets the maximum distance between linked scans. Scans that are farther apart will not be linked regardless of the correlation response value.
loop_search_maximum_distance	double	4.0	Scans less than this distance from the current position will be considered for a match in loop closure.
do_loop_closing	bool	true	Enable/disable loop closure.
loop_match_minimum_chain_size	int	10	When the loop closure detection finds a candidate it must be part of a large set of linked scans
loop_match_maximum_variance_coarse	double	math::Square(0.4)=0.16	The co-variance values for a possible loop closure have to be less than this value to consider a viable solution. This applies to the coarse search.

Parameters	Type	Defaults value	Description
loop_match_minimum_response_coarse	double	0.8	If response is larger than this, then initiate loop closure search at the coarse resolution.
loop_match_minimum_response_fine	double	0.8	If response is larger than this, then initiate loop closure search at the fine resolution.

- Correction parameters

Parameters	Type	Defaults value	Description
correlation_search_space_dimension	double	0.3	Sets the size of the search grid used by the matcher.
correlation_search_space_resolution	double	0.01	Sets the resolution (size of a grid cell) of the correlation grid.
correlation_search_space_smear_deviation	double	0.03	The point readings are smeared by this value in X and Y to create a smoother response.

- Loopback parameters

Parameters	Type	Defaults value	Description
loop_search_space_dimension	double	8.0	The size of the search grid used by the matcher.
loop_search_space_resolution	double	0.05	The resolution (size of a grid cell) of the correlation grid.
loop_search_space_smear_deviation	double	0.03	The point readings are smeared by this value in X and Y to create a smoother response.

- Scan Matcher parameters

Parameters	Type	Defaults value	Description
distance_variance_penalty	double	sqrt(0.3)=0.09(<1.0)	Variance of penalty for deviating from odometry when scan-matching. The penalty is a multiplier (less than 1.0) is a function of the delta of the scan position being tested and the odometric pose.
angle_variance_penalty	double	sqrt(deg2rad(20))=0.17453292	See distance_variance_penalty.
fine_search_angle_offset	double	deg2rad(0.2)=0.0017453292	The range of angles to search during a fine search.
coarse_search_angle_offset	double	deg2rad(20)=0.17453292	The range of angles to search during a coarse search.
coarse_angle_resolution	double	deg2rad(2)=0.017453292	Resolution of angles to search during a coarse search.
minimum_angle_penalty	double	0.9	Minimum value of the angle penalty multiplier so scores do not become too small.
minimum_distance_penalty	double	0.5	Minimum value of the distance penalty multiplier so scores do not become too small.
use_response_expansion	bool	false	Whether to increase the search space if no good matches are initially found

4) TF Transforms

Required tf Transforms	**Description**
laser-->base_link	usually a fixed value, broadcast periodically by a robot_state_publisher, or a `tf` static_transform_publisher.
base_link-->odom	usually provided by the odometry system (e.g., the driver for the mobile base)
Provided tf TransformsTF	**Description**
map-->odom	the current estimate of the robot's pose within the map frame

6.2.4、cartographer

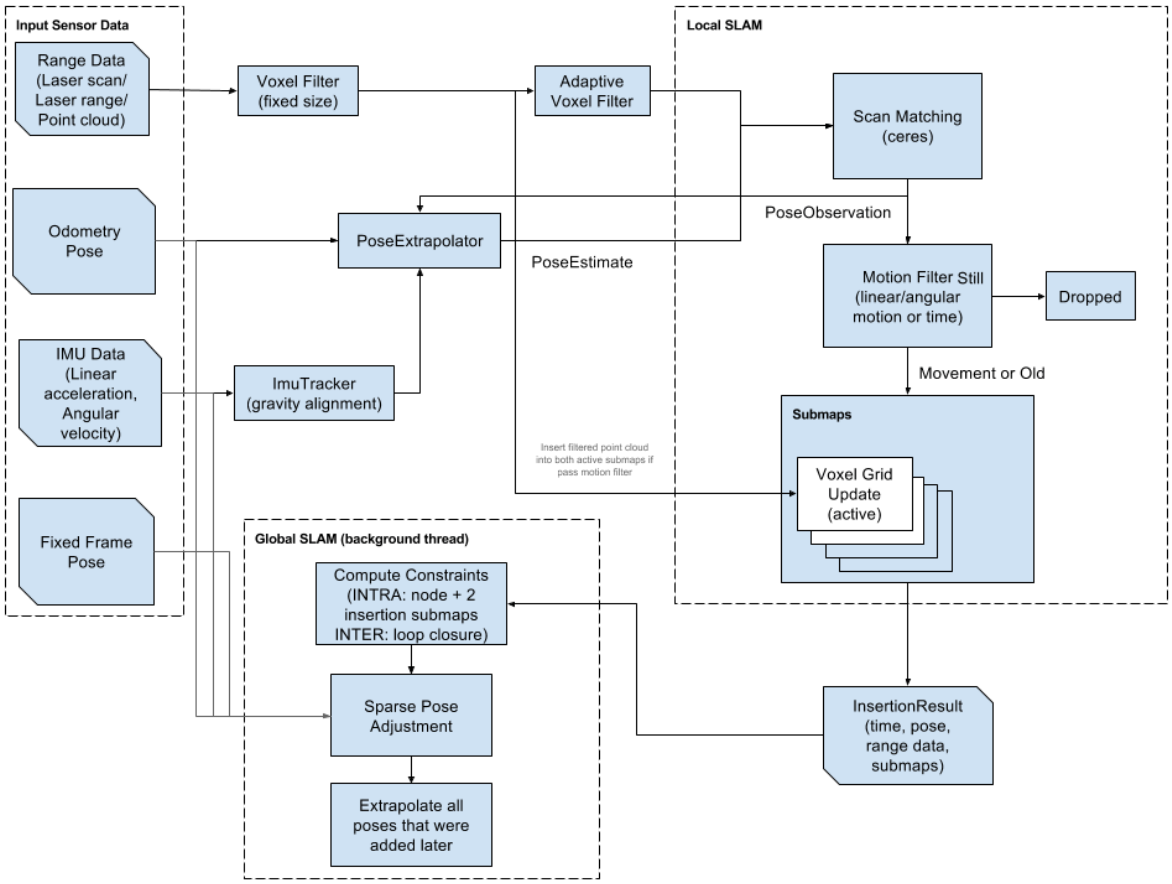
1) Introduction

Cartographer is a 2D and 3D SLAM (simultaneous localization and mapping) library supported by a ROS system open sourced by Google. A graph-building algorithm based on graph optimization (multi-threaded back-end optimization, problem optimization built by cere). Data from multiple sensors (for example, LIDAR, IMU, and camera) can be combined to calculate the position of the sensor simultaneously and map the environment around the sensor.

2) Code structure

The source code of cartographer mainly includes three parts: cartographer、cartographer_ros and ceres-solver 。

- cartographer



- cartographer_ros

The package cartographer_ros runs in the ROS system. It can receive various sensor data in the form of ROS messages, and publish it in the form of messages after processing, which is convenient for debugging and visualization.

3) Parameters

lua file

Parameters	Description
map_frame	Map coordinate system
tracking_frame	Convert all sensor data to this coordinate system
published_frame	The map points to coordinate system the
odom_frame	If true, the tf tree is map->odom->footprint; if false, the tf tree is map->footprint
provide_odom_frame	If true, the local, non-loop-closed, continuous pose will be published as odom_frame in map_frame
publish_frame_projected_to_2d	If enabled, the published pose will restrict 2D poses
use_odometry	Whether to use the odometer, if you use it, you must have odom tf
use_nav_sat	Whether to use gps
use_landmarks	Whether to use landmark
num_laser_scans	Whether to use single-line laser data
num_multi_echo_laser_scans	Whether to use multi_echo_laser_scans data
num_subdivisions_per_laser_scan	1 frame of data is divided into several processings, in generally it is 1
num_point_clouds	Whether to use point cloud data
lookup_transform_timeout_sec	Find the timeout of tf
submap_publish_period_sec	Time interval for publishing submap (seconds)
pose_publish_period_sec	The time interval for posting pose, when the value is 5e-3, it is 200HZ
trajectory_publish_period_sec	The time interval for publishing trajectory markers (trajectory nodes), the value is 30e-3 to 30ms
rangefinder_sampling_ratio	Fixed sampling frequency of lidar messages
odometry_sampling_ratio	Fixed sampling frequency of odometer messages
fixed_frame_pose_sampling_ratio	Fixed sampling frequency of fixed coordinate system messages
imu_sampling_ratio	Fixed sampling frequency of IMU messages
landmarks_sampling_ratio	Fixed sampling frequency for road sign messages

6.3、rrt_exploration

6.3.1、Introduction

RRT exploration is a search algorithm based on the RRT path planning algorithm.

RRT algorithm is as follows:

- Global RRT frontier point detector node.
- Local RRT frontier point detector node.
- OpenCV-based frontier detector node.
- Filter node.
- Assigner node.

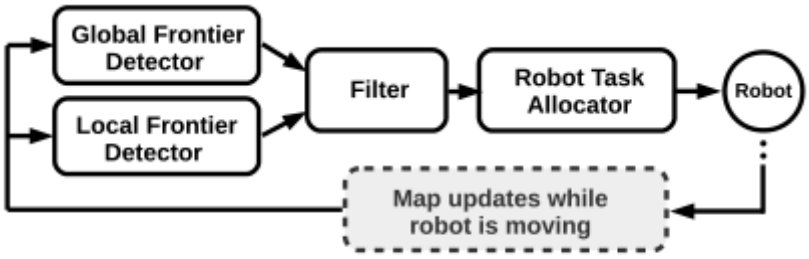


Fig. 1: Overall schematic diagram of the exploration algorithm

There are 3 types of nodes: nodes used to detect boundary points occupying the grid map, nodes used to filter detected points, and nodes used to assign points to robots.

6.3.2、global_rrt_frontier_detector

1) Introduction

The global_rrt_frontier_detector node uses the occupancy grid and finds boundary points (that is, exploration targets) in it. It publishes the detected points so that the filter nodes can process them. In a multi-robot configuration, only one instance of this node is run.

2) Topics and Services

Subscribed Topics	Type	Description
map	nav_msgs/OccupancyGrid	The topic name is defined by the ~map_Topic parameter. It is the name of the topic that the node receives.
clicked_point	geometry_msgs/PointStamped	The area to be detected by the global_rrt_frontier_detector node. This topic is where the node receives the five points that define the area. The first four points are the four points that define the square area to be explored, and the last point is the starting point of the tree. After the announcement of these five points, the RRT will begin to detect border points.
Published Topics	**Type**	**Description**
detected_points	geometry_msgs/PointStamped	Post the topic of the detected boundary point.
shapes	visualization_msgs/Marker	Publish RRT hypothetical line type to view with Rviz.

3) Parameters

Parameters	Type	Defaults value	Description
~map_topic	string	"/robot_1/map"	The node receives the map topic mapping name
~eta	float	5.0	This parameter controls the growth rate of RRT used to detect boundary points, in meters.

6.3.3、local_rrt_frontier_detector

1) Introduction

This node is similar to global_rrt_frontier_detector. However, it works differently, because every time a boundary point is detected, the tree here is constantly reset. This node will run along the global boundary detector node, which is responsible for quickly detecting boundary points located near the robot.

2) Topics and Services

Subscribed Topics	Type	Description
map	nav_msgs/OccupancyGrid	The name of the map topic subscribed by this node.
clicked_point	geometry_msgs/PointStamped	Similar to the global_rrt_frontier_detector node
Published Topics	**Type**	**Description**
detected_points	geometry_msgs/PointStamped	Post the topic of the detected boundary point.
shapes	visualization_msgs/Marker	Publish RRT hypothetical line type to view with Rviz.

3) Parameters

Parameters	Type	Defaults value	Description
~/robot_1/base_link	string	"/robot_1/base_link"	Connect to the frame of the robot. Each time the RRT tree is reset, it will start from the current robot position obtained in this coordinate system.
~map_topic	string	"/robot_1/map"	The node receives the map topic mapping name
~eta	float	5.0	This parameter controls the growth rate of RRT used to detect boundary points, in meters.

6.3.4、frontier_opencv_detector

1) Introduction

This node is another boundary detector, but it is not based on RRT.

2) Topics and Services

Subscribed Topics	Type	Description
map	nav_msgs/OccupancyGrid	The name of the map topic subscribed by this node.
Published Topics	**Type**	**Description**
detected_points	geometry_msgs/PointStamped	Post the topic of the detected boundary point.
shapes	visualization_msgs/Marker	Publish RRT hypothetical line type to view with Rviz.

3) Parameters

Parameters	Type	Defaults value	Description
~map_topic	string	"/robot_1/map"	The node receives the map topic mapping name

6.3.5、filter

1) Introduction

The node node receives the detected boundary points from all detectors, filters these points, and passes them to the distribution node to command the robot. Filtering includes deleting old points and invalid points, as well as deleting redundant points.

2) Topics and Services

Subscribed Topics	Type	Description
map	nav_msgs/OccupancyGrid	The topic name is defined by the ~map_Topic parameter. It is the name of the topic that the node receives.
robot_x/move_base_node /global_costmap/costmap	nav_msgs/OccupancyGrid	x is the number of the robot. This node subscribes to the topics of all cost maps of all robots, so costmap is needed.
detected_points	geometry_msgs/PointStamped	The name of the topic defined by ~goals_topic. It is the topic of the filter node receiving boundary detection points.
Published Topics	**Type**	**Description**
frontiers	visualization_msgs/Marker	The filter node only publishes the topics of the filtered boundary points.
centroids	visualization_msgs/Marker	The filter node publishes the topic of the received boundary point.
filtered_points	MsgLink(msg/type)	All filtered points are sent to the assigner node of this topic as a point array.

3) Parameters

Parameters	Type	Defaults value	Description
~map_topic	string	"/robot_1/map"	The node receives the map topic mapping name
~costmap_clearing_threshold	float	70.0	Cost map cleanup threshold
~info_radius	float	1.0	The information radius used to calculate the information gain of the boundary point.
~goals_topic	string	/detected_points	Define the subject of the node receiving the detection boundary point
~n_robots	float	1.0	Number of robots
~namespace	string		Namespaces
~namespace_init_count	float	1.0	Namespace index
~rate	float	100.0	Node cycle rate (in Hz).

6.3.6、Assigner

1) Introduction

The node receives the target detection target, that is, the filtering boundary point issued by the filtering node, and commands the robot accordingly. The evaluator node commands the robot through move_base_node. This is why the navigation is started on the robot.

2) Topics and Services

Subscribed Topics	Type	Description
map	nav_msgs/OccupancyGrid	The topic name is defined by the ~map_Topic parameter. It is the name of the topic that the node receives.
frontiers_topic	nav_msgs/OccupancyGrid	The topic name is defined by the ~frontiers_topic parameter

3) Parameters

Parameters	Type	Defaults value	Description
~map_topic	string	"/robot_1/map"	The node receives the map topic mapping name
~info_radius	float	1.0	The information radius used to calculate the information gain of the boundary point.
~info_multiplier	float	3.0	The unit is meters. .
~hysteresis_radius	float	3.0	The unit is meters. This parameter defines the hysteresis radius.
~hysteresis_gain	float	2.0	The unit is meters. This parameter defines the hysteresis gain.
~frontiers_topic	string	/filtered_points	The node receives the topic of the boundary point.
~n_robots	float	1.0	Number of robots
~namespace	string		Namespaces
~namespace_init_count	float	1.0	Starting the index of the robot name.
~delay_after_assignement	float	0.5	The unit is seconds. It defines the amount of delay after each robot allocation.
~global_frame	string	"/map"	Used in the global coordinate system. In a single robot, it is the same as the "map_topic" parameter. In the case of multiple robots, the coordinate system name corresponds to the global coordinate system name.