8.karto mapping algorithm

karto： http://wiki.ros.org/slam_karto

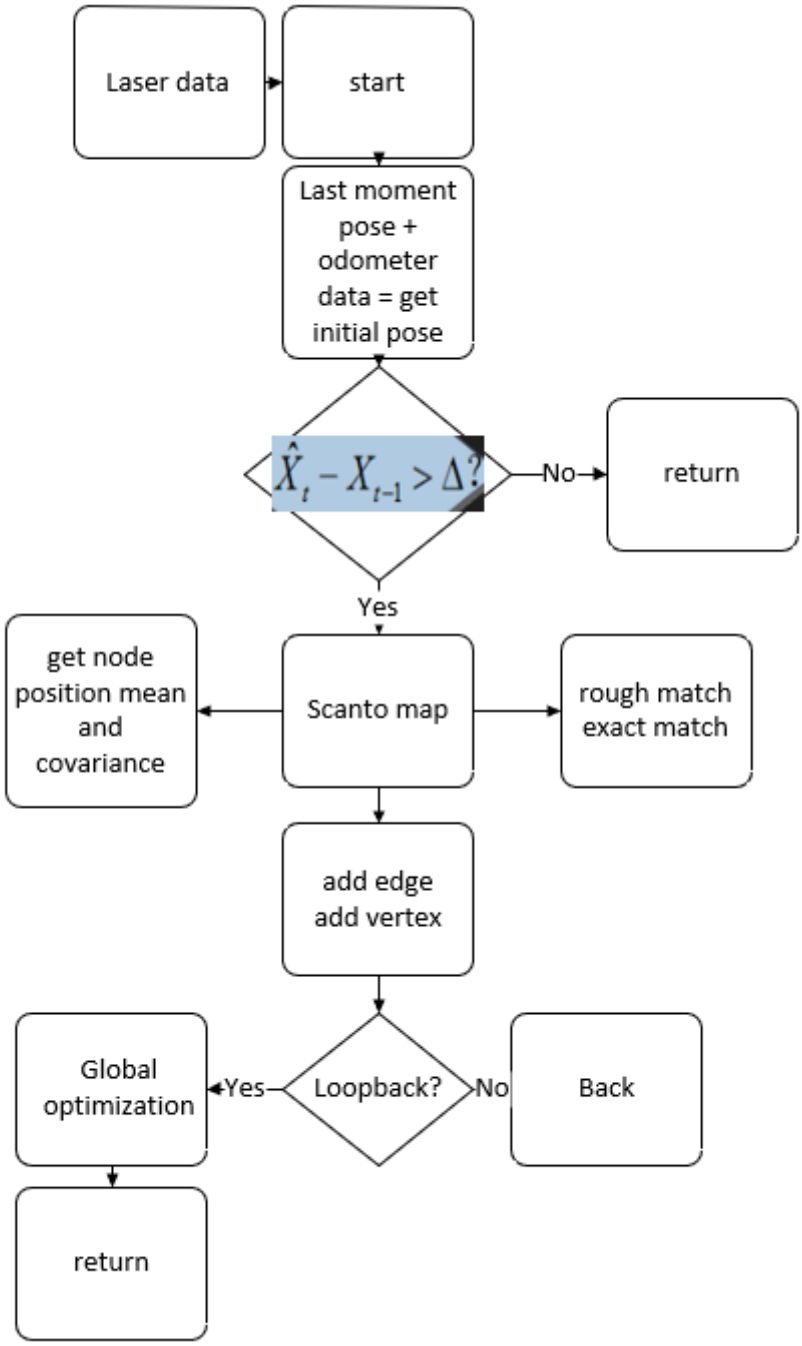
map_server： https://wiki.ros.org/map_server

8.1 Introduction

Karto is a 2D laser SLAM solution based on sparse graph optimization with loop closure detection. The graph optimization method uses the mean value of the graph to represent the map, and each node represents a position point of the robot trajectory and a sensor measurement data set. Karto uses the spa(karto_slam) or g2o(nav2d) optimization library, and the front-end and back-end are single-threaded.

The ROS version of Karto_SLAM, which employs the Spare Pose Adjustment(SPA) related to scan matching and loop closure detection. The more landmarks there are, the greater the memory requirements. However, the graph optimization method has greater advantages in mapping compared to other methods in a large environment, because it only contains the robot pose of the point, and then the map is obtained after the pose is obtained.

overall program framework



8.2 Use

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

According to different models, you only need to set the purchased model in [.bashrc], X1(ordinary four-wheel drive) X3(Mike wheel) X3plus(Mike wheel mechanical arm) R2(Ackerman differential) and so on. Section takes X3 as an example

Open the [.bashrc] file

```
sudo vim .bashrc
```

Find the [ROBOT_TYPE] parameter and modify the corresponding model

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

8.2.1 Start

Start command(robot side), for the convenience of operation, this section takes [mono + laser + yahboomcar] as an example.

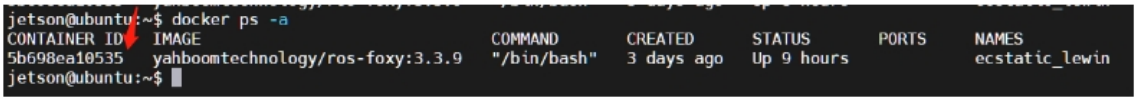
```
#You need to enter docker first, perform this step more
#If running the script to enter docker fails, please refer to 07.Docker-orin/05,
Enter the robot's docker container
~/run_docker.sh
roslaunch yahboomcar_nav laser_bringup.launch           # laser + yahboomcar
roslaunch yahboomcar_nav laser_usb_bringup.launch       # mono + laser +
yahboomcar
roslaunch yahboomcar_nav laser_astrapro_bringup.launch  # Astra + laser +
yahboomcar
```

Mapping command(robot side)

<Open another terminal and 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
```

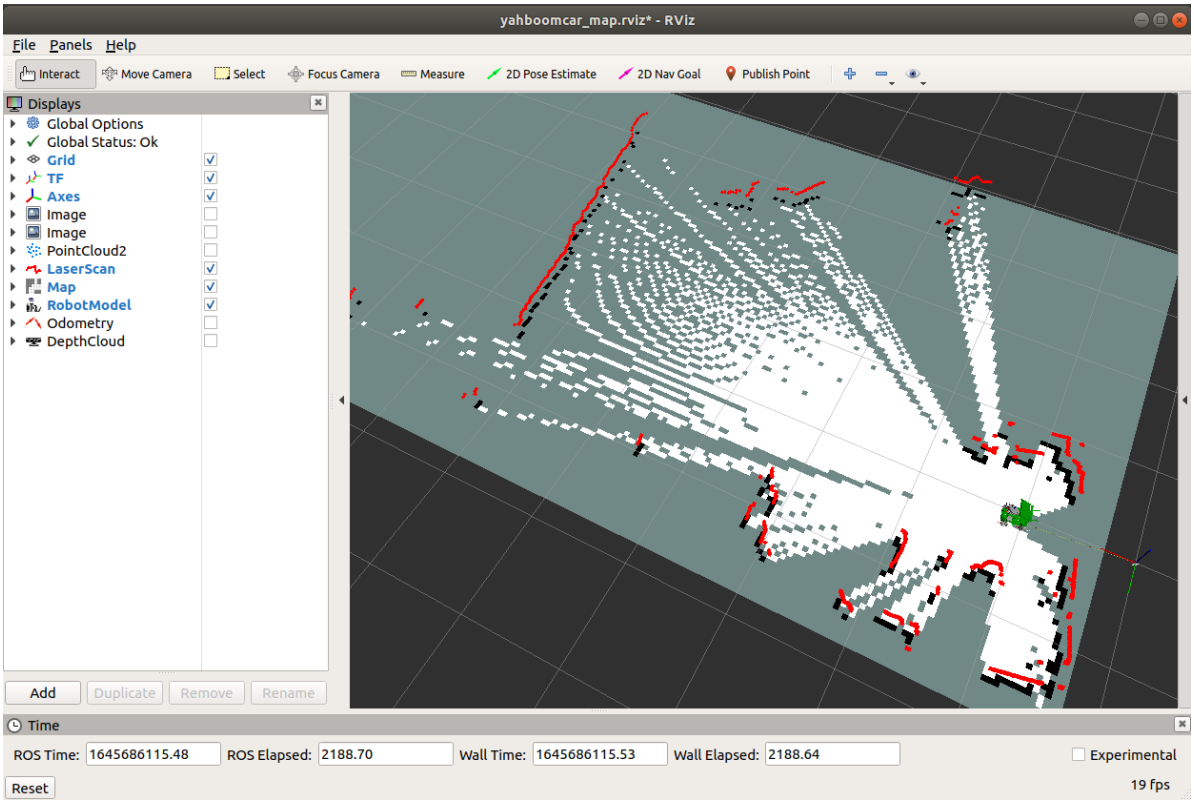
After successfully entering the container, you can open countless terminals to enter the container.

```
roslaunch yahboomcar_nav yahboomcar_map.launch use_rviz:=false
map_type:=karto
```

- [use_rviz] parameter: whether to enable rviz visualization.
- [map_type] parameter: set the mapping algorithm [karto].

Open the visual interface(virtual machine side)

```
roslaunch yahboomcar_nav view_map.launch
```



The gap at the back of the robot is due to the occlusion of the installation position of the display screen, so a certain range of Lidar data is shielded. The shielding range can be adjusted or not shielded according to the actual situation. For details, see [01. Lidar Basic Course].

8.2.2 Control the robot

- The keyboard controls the movement of the robot

```
roslaunch yahboomcar_ctrl yahboom_keyboard.launch       # custom
```

- The handle controls the movement of the robot

Make the robot walk all over the area to be built, and the map is as closed as possible.

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

8.2.3 Map save

```
rosrun map_server map_saver -f ~/yahboomcar_ws/src/yahboomcar_nav/maps/my_map
# The first way
bash ~/yahboomcar_ws/src/yahboomcar_nav/maps/map.sh
# second way
```

The map will be saved to ~/yahboomcar_ws/src/yahboomcar_nav/maps/ folder, a pgm image, 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 parsing:

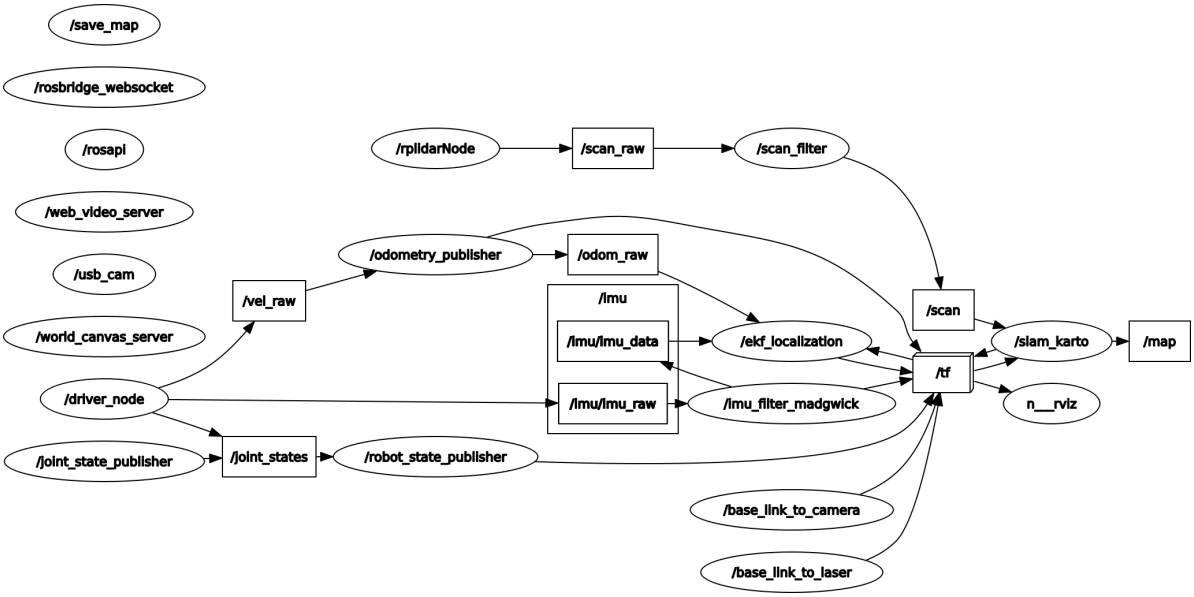
- image: The path of the map file, which can be an absolute path or a relative path
- resolution: the resolution of the map, m/pixel
- origin: The 2D pose(x, y, yaw) of the lower left corner of the map, where yaw is rotated counterclockwise(yaw=0 means no rotation). Many parts of the system currently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

8.3 Topics and Services

Topic subscription	**type**	**describe**
scan	sensor_msgs/LaserScan	Depth data from lidar scans
tf	tf/tfMessage	Used to convert between lidar coordinate system, base coordinate system, and odometer coordinate system
Topic release	**type**	**describe**
map_metadata	nav_msgs/MapMetaData	Publish map Meta data
map	nav_msgs/OccupancyGrid	Publish map raster data
visualization_marker_array	visualisation_msgs/MarkerArray	Post pose diagram
Serve	**type**	**describe**
dynamic_map	nav_msgs/GetMap	Get map data

Node view

```
rqt_graph
```



8.4 configuration parameters

- General parameters

parameter	type	Defaults	illustrate
~base_frame	string	"base_link"	Robot base coordinate system
~map_frame	string	"map"	map coordinate system
~odom_frame	string	"odom"	Odometer Coordinate System
~throttle_scans	int	1	Process 1 every so many scans(set it to a higher number to skip more scans)
~map_update_interval	float	5.0	The interval in seconds between map updates. Lowering this number updates the occupancy grid more frequently, but increases the computational load.
~resolution	float	0.05	Map resolution(meters per occupied grid block)
~delta	float	0.05	Map resolution(meters per occupied grid block). Same as resolution. Defined for compatibility with gmapping parameter names.
~transform_publish_period	float	0.05	The interval(in seconds) between transition publications.
use_scan_matching	bool	true	Whether to use the scan matching algorithm, generally set to true, the mapper algorithm can correct the noise and error of the odometer and the laser. In some simulation environments with accurate sensor data, the scan matching algorithm will get worse results(because of the use of Gaussian blur, which reduces the observation confidence of high-precision sensors), it is recommended to close(add noise to the simulation environment).
use_scan_barycenter	bool	true	Use the centroids of the scan endpoints to define the distance 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 angle between scans.
scan_buffer_size	int	70	Set the length of ScanBuffer, approximately equal to scan_buffer_maximum_scan_distance/minimum_travel_distance
scan_buffer_maximum_scan_distance	double	20.0	Setting the maximum length of ScanBuffer is similar to Size
link_match_minimum_response_fine	double	0.8	Set minimum response threshold for minimum scans connections
link_scan_minimum_distance	double	10.0	Set the maximum distance of scans between two connections. If it is greater than this value, the response threshold of the two will not be considered.
loop_search_maximum_distance	double	4.0	Loopback detection maximum distance. Scans less than this distance from the current position will be considered matched loop closures.
do_loop_closing	bool	true	Whether to enable loopback detection
loop_match_minimum_chain_size	int	10	Loop detection minimum chain size
loop_match_maximum_variance_coarse	double	math::Square(0.4)=0.16	The maximum covariance value of rough matching during loopback matching, if it is less than this value, it is considered a feasible solution
loop_match_minimum_response_coarse	double	0.8	The minimum response of coarse matching during loopback matching. If the response value is greater than this value, coarse-precision loopback optimization will start.
loop_match_minimum_response_fine	double	0.8	The loopback matches the minimum response threshold, and if it is greater than this value, the high-precision starts

- Correction parameters

parameter	type	Defaults	illustrate
correlation_search_space_dimension	double	0.3	Set the search range size of the Correlation Grid
correlation_search_space_resolution	double	0.01	Set the resolution of the Correlation Grid
correlation_search_space_smear_deviation	double	0.03	Set the Correlation Grid blur level

- loopback parameters

parameter	type	Defaults	illustrate
loop_search_space_dimension	double	8.0	Loopback detection space range size
loop_search_space_resolution	double	0.05	Loop Closure Detection Spatial Resolution
loop_search_space_smear_deviation	double	0.03	Loop closure detection blur level

- Scan Matcher parameters

parameter	type	Defaults	illustrate
distance_variance_penalty	double	sqrt(0.3)=0.09(less than 1.0)	Compensation factor for odometer during scan-matching
angle_variance_penalty	double	sqrt(deg2rad(20))=0.17453292	Compensation coefficient for angle during scan-matching
fine_search_angle_offset	double	deg2rad(0.2) = 0.0017453292	Refine search angle range
coarse_search_angle_offset	double	deg2rad(20) = 0.17453292	Rough search angle range
coarse_angle_resolution	double	deg2rad(2) = 0.017453292	Coarse search angle resolution
minimum_angle_penalty	double	0.9	Minimum angle penalty
minimum_distance_penalty	double	0.5	minimum distance penalty
use_response_expansion	bool	false	Whether to increase the search scope if no good matches are found

8.5 TF transformation

Required TF Transform	**describe**
laser-->base_link	Usually a fixed value, the transformation between the lidar coordinate system and the base coordinate system is generally published by robot_state_publisher or static_transform_publisher
base_link-->odom	The transformation between the map coordinate system and the robot's odometer coordinate system to estimate the robot's pose in the map
Published TF Transform	**describe**
map-->odom	The current estimate of the robot pose within the map frame(only provided if parameter "pub_map_odom_transform" is true).

View tf tree

```
rosrun rqt_tf_tree rqt_tf_tree
```