7、Navigation obstacle avoidance

amcl：http://wiki.ros.org/amcl

navigation：http://wiki.ros.org/navigation/

navigation/Tutorials：http://wiki.ros.org/navigation/Tutorials/RobotSetup

costmap_2d：http://wiki.ros.org/costmap_2d

nav_core：http://wiki.ros.org/nav_core

global_planner：http://wiki.ros.org/global_planner

dwa_local_planner：http://wiki.ros.org/dwa_local_planner

teb_local_planner：http://wiki.ros.org/teb_local_planner

move_base：http://wiki.ros.org/move_base

depthimage_to_laserscan：http://wiki.ros.org/depthimage_to_laserscan

Function package：~/rplidar/src/transbot_nav

7.1、Usage

Note: [R2] on the handle can cancel the target point.

7.1.1、Start up

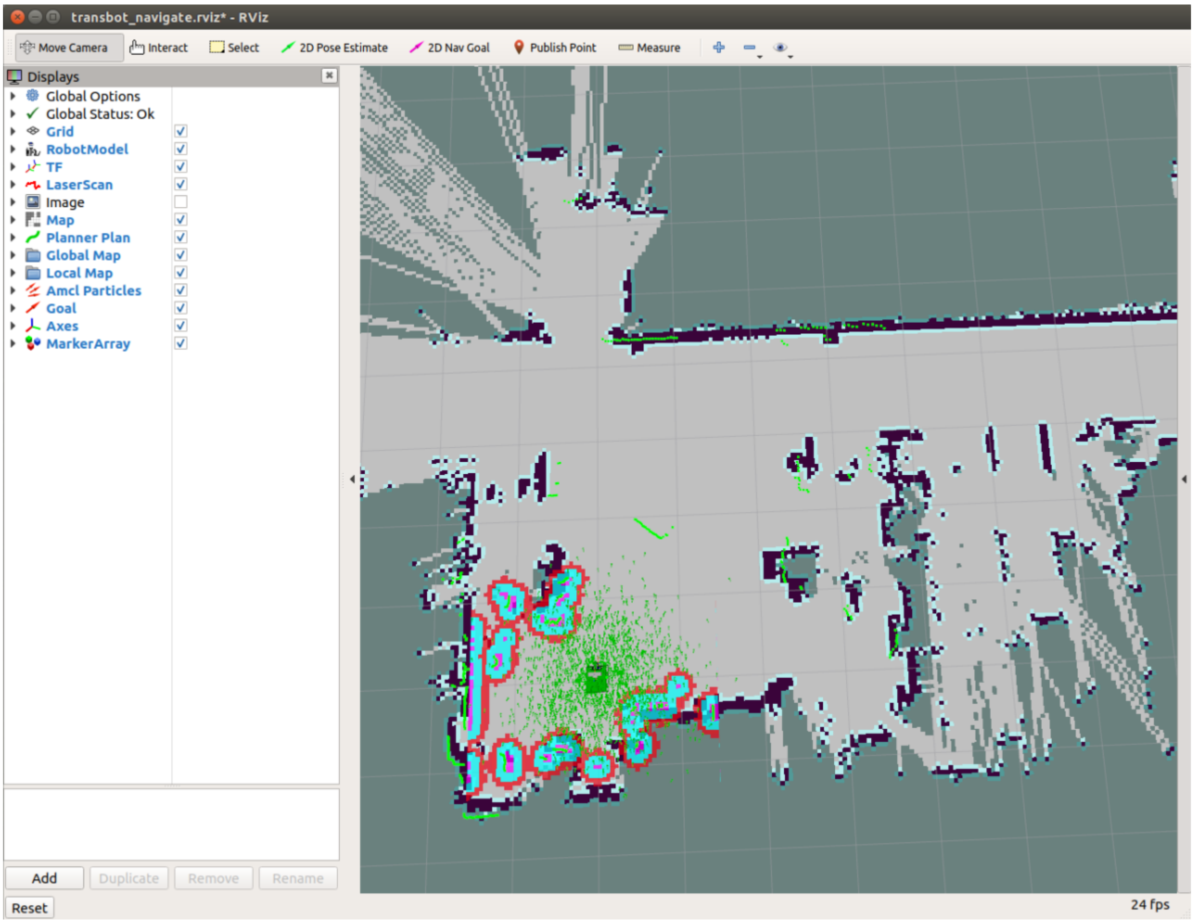
Start the driver and start it according to your needs (note: the pure depth mapping navigation effect is not good, so it is not recommended).

```
roslaunch transbot_nav usbcam_bringup.launch  lidar_type:=a1  # mono + laser + Transbot
roslaunch transbot_nav astra_bringup.launch     # Astra + Transbot
roslaunch transbot_nav laser_bringup.launch lidar_type:=a1   # laser + Transbot
roslaunch transbot_nav transbot_bringup.launch lidar_type:=a1 # Astra + laser + Transbot
```

Start the navigation obstacle avoidance function, you can set the parameters according to your needs, and you can also modify the launch file.

```
roslaunch transbot_nav transbot_navigation.launch open_rviz:=true map:=house
```

- open_rviz parameter: whether to open rviz.
- map: name of the map, the map to be loaded.



7.1.2、Usage

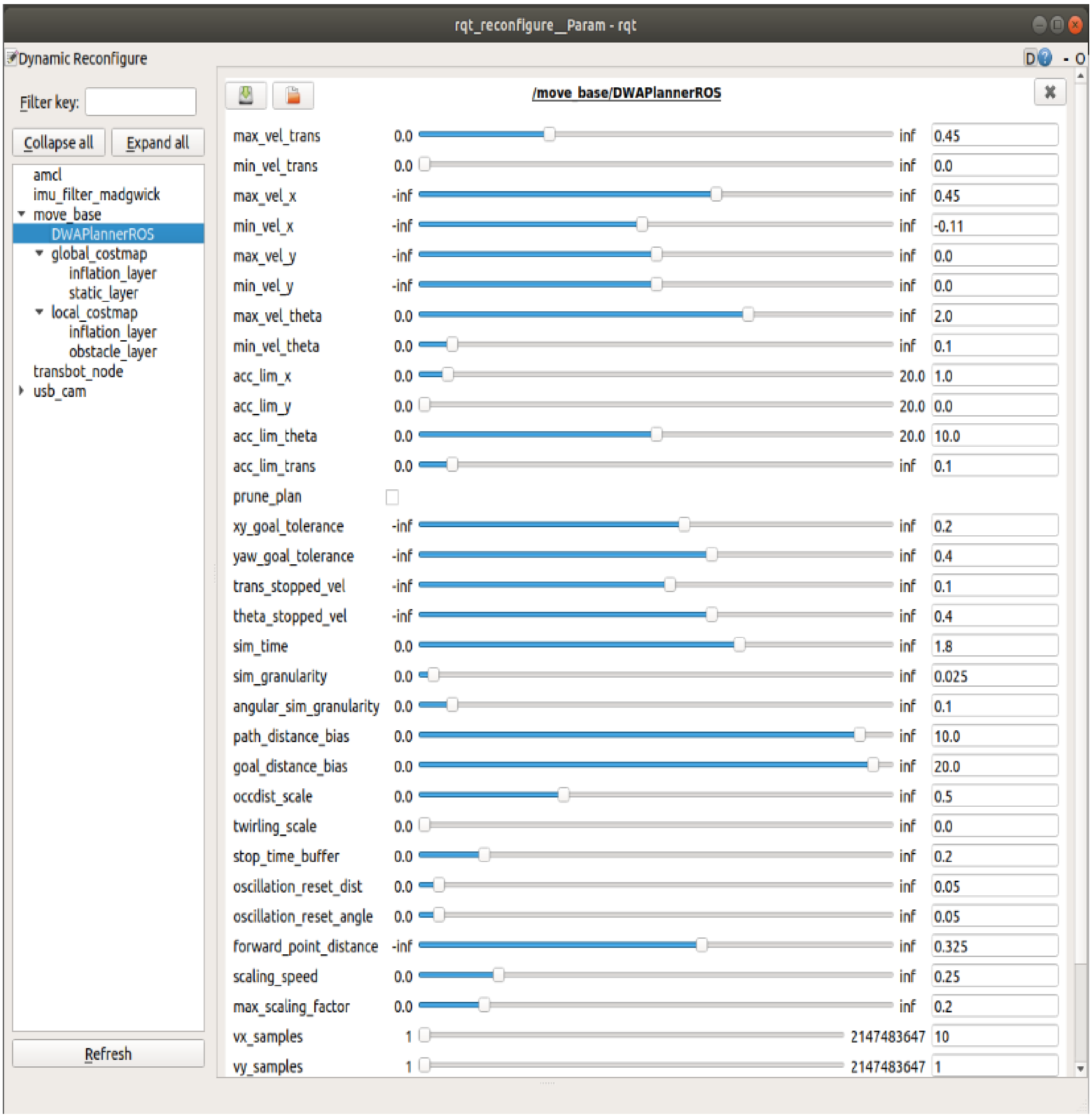
- Place the robot at the origin. If the radar scanning edge does not coincide with the map, we need to use the 【2D Pose Estimate】of the 【rviz】 tool to set the initial pose.
  If the robot cannot find the pose in the map, it also needs to set the initial pose.
- Single-point navigation:

  Click the 【2D Nav Goal】 of the 【rviz】tool. Then use the mouse to select a target point on the map model where there are no obstacles. Release the mouse to start the navigation. Only one target point can be selected. Finally, robot car will move towards the target point form, after reaching the target point, the car will stop.
- Multi-point navigation:

  Click 【Publish Point】of the 【rviz】tool. Then select a target point where there are no obstacles on the map model, release the mouse to start navigation. You can click 【Publish Point】again, then select others point. Finally, robot car will cruise from point to point.

7.1.3、Dynamic parameter adjustment

```
rosrun rqt_reconfigure rqt_reconfigure
```



You can check the relationship between the node and the tf tree

```
rqt_graph
rosrun rqt_tf_tree rqt_tf_tree
```

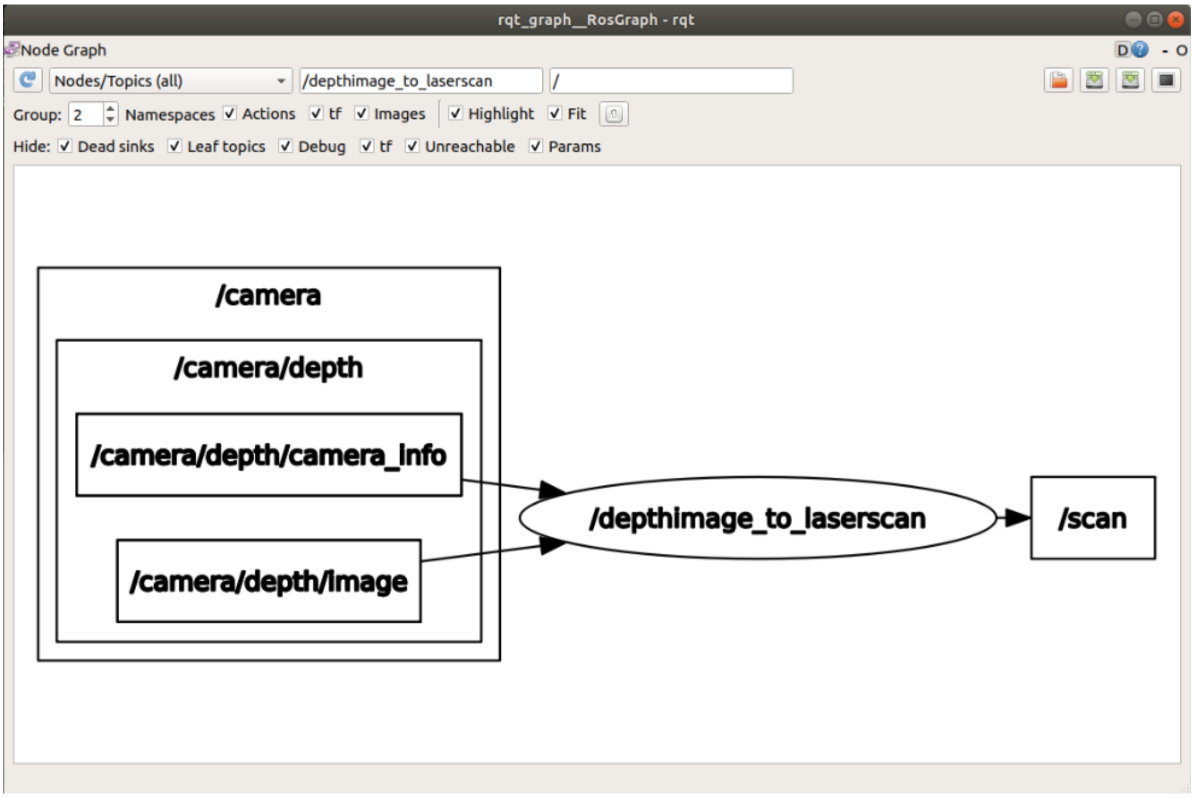
7.1.4、2D navigation by depth mapping alone

Start the driver reference【7.1.1】# Astra + Transbot; the command for starting the map is the same as【7.1.1】.

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°.

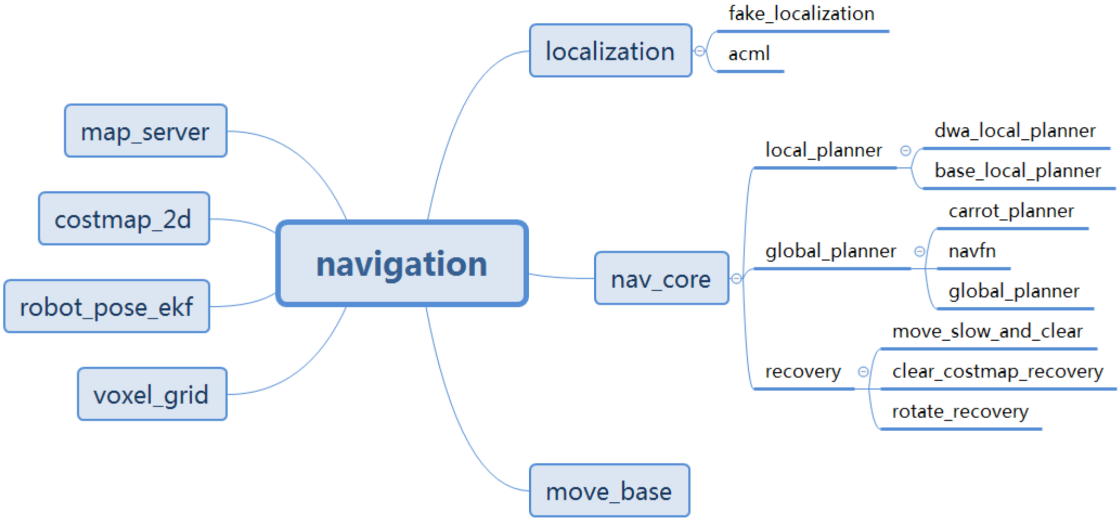
```
rqt_graph
```



7.2、navigation

7.2.1、Introduction

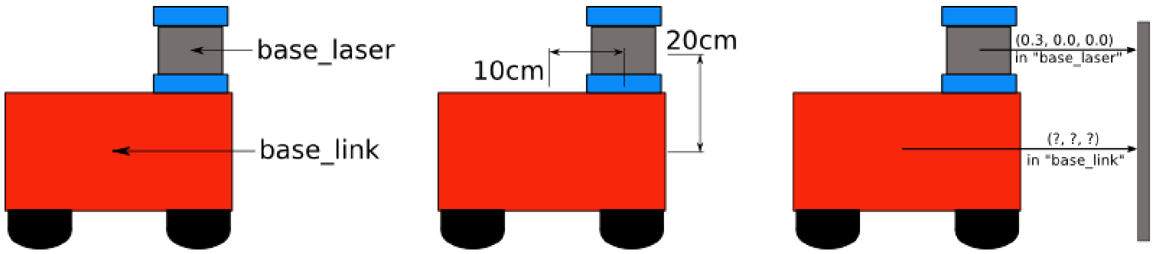
navigation is a 2D navigation obstacle avoidance function package of ROS.



7.2.2、 Setting tf

The navigation function requires the robot to use tf to publish information about the relationship between coordinate systems.

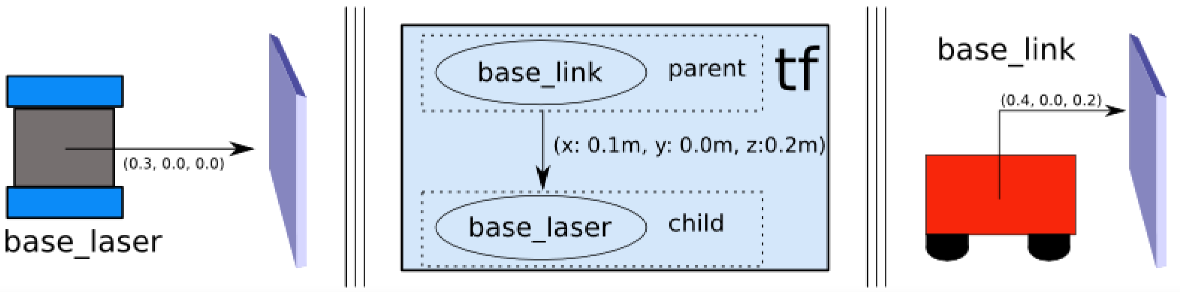
Example: Lidar



If we know that the lidar is installed at 10 cm and 20 cm above the center point of the mobile base.

This gives us the translation offset that associates the "base_link" frame with the "base_laser" frame.

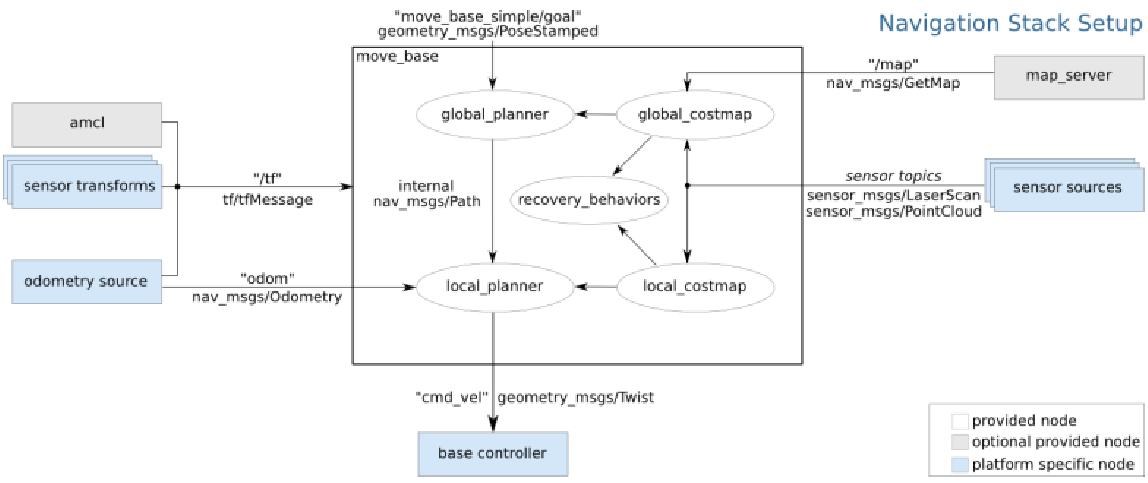
Specifically, we know that to get data from the "base_link" coordinate system to the "base_laser" coordinate system, we must apply the translation of (x: 0.1m, y: 0.0m, z: 0.2m) and move from the "base_laser" frame To the "base_link" frame, we must apply the opposite translation (x: -0.1m, y: 0.0m, z: -0.20m).



7.3、move_base

7.3.1、Introduction

move_base provides the configuration, operation, and interactive interface of ROS navigation.



Realize the robot navigation function, it must be configured in a specific way, as shown in the figure above.

- White components are required components that have been implemented,
- Gray components are optional components that have been implemented,
- Blue component must be created for each robot platform.

7.3.2、move_base communication mechanism

1) Action

The move_base node provides an implementation of SimpleActionServer, which receives the target containing the geometry_msgs/PoseStamped message.

You can directly communicate with the move_base node through ROS, but if you are concerned about tracking the status of the target, it is recommended to use SimpleActionClient to send the target to move_base.

Name	Type	Explanation
move_base/goal	move_base_msgs/MoveBaseActionGoal	move_base subscription will reach the target point.
move_base/cancel	actionlib_msgs/GoalID	move_base subscription cancels a request for a specific target
move_base/feedback	move_base_msgs/MoveBaseActionFeedback	publish contains the current position of the chassis.

Name	Type	Explanation
move_base/status	actionlib_msgs/GoalStatusArray	publish the status information of the process of moving to the target point.
move_base/result	move_base_msgs/MoveBaseActionResult	post the final result of the move.

2) topic

Name	Type	Explanation
move_base_simple/goal	geometry_msgs/PoseStamped	Provides a non-action interface for not paying attention to the execution state of the tracking target. The move_base subscription will reach the target point.
cmd_vel	geometry_msgs/Twist	Release the speed of the car.

3) servies

Name	Type	Explanation
make_plan	nav_msgs/GetPlan	Allow external users to request a plan for a given posture from move_base without causing move_base to execute the plan.
clear_unknown_space	std_srvs/Empty	Allow external users to notify move_base to clear the unknown space around the robot. This is very useful when the costmaps of move_base are stopped for a long period of time and then restarted at a new location in the environment.
clear_costmaps	std_srvs/Empty	Allow external users to tell move_base to remove obstacles in the cost map used by move_base. This may cause the robot to hit something, so be careful when using it

4) Parameter configuration

move_base_params.yaml

```
# Set the plugin name of the global path planner for move_base
#base_global_planner: "navfn/NavfnROS"
base_global_planner: "global_planner/GlobalPlanner"
#base_global_planner: "carrot_planner/CarrotPlanner"

# Set the plugin name of the local path planner of move_base
```

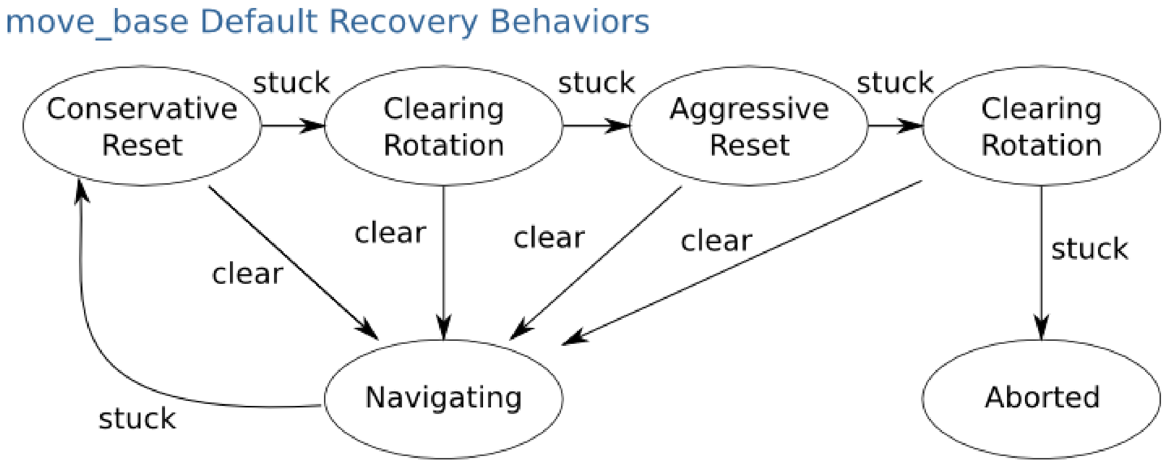
```
#base_local_planner: "teb_local_planner/TebLocalPlannerROS" # Implement DWA
(Dynamic Window Method) local planning algorithm
base_local_planner: "dwa_local_planner/DWAPlannerROS"       # Realize an online
optimized local trajectory planner
# Recovery behavior
recovery_behaviors:
  - name: 'conservative_reset'
    type: 'clear_costmap_recovery/ClearCostmapRecovery'
  #- name: 'aggressive_reset'
  #  type: 'clear_costmap_recovery/ClearCostmapRecovery'
  #- name: 'super_reset'
  #  type: 'clear_costmap_recovery/ClearCostmapRecovery'
  - name: 'clearing_rotation'
    type: 'rotate_recovery/RotateRecovery'
    #- name: 'move_slow_and_clear'
    #type: 'move_slow_and_clear/MoveSlowAndClear'

# Frequency of sending commands to the robot chassis cmd_vel
controller_frequency: 10.0 #default:20.0
# The time that the path planner waits for a valid control command before the
space cleanup operation is executed
planner_patience: 5.0 #default:5.0
# Time the controller waits for a valid control command before the space clearing
operation is executed
controller_patience: 15.0 #default:15.0
# Use this parameter only when the default recovery behavior is used for
move_base.
conservative_reset_dist: 3.0 #3.0,
# Whether to enable move_base recovery behavior to try to clear space.
recovery_behavior_enabled: true
# Whether the robot uses in-situ rotation to clean up the space, this parameter
is only used when the default recovery behavior is used.
clearing_rotation_allowed: true
# When move_base enters the inactive state, whether to disable the costmap of the
node
shutdown_costmaps: false #false
# Allowed shock time before performing the recovery operation, 0 means never
timeout
oscillation_timeout: 10.0 #0.0
# The robot needs to move this distance before it can be considered as having no
vibration. Reset timer parameters after moving
oscillation_distance: 0.2 #0.5
# The global path planner cycle rate.
planner_frequency: 5.0 #0.0
# The number of planned retries allowed before performing the recovery action.
The value -1.0 corresponds to unlimited retries.
max_planning_retries: -1.0
```

-

7.3.3、Recovery Behavior

1) Introduction

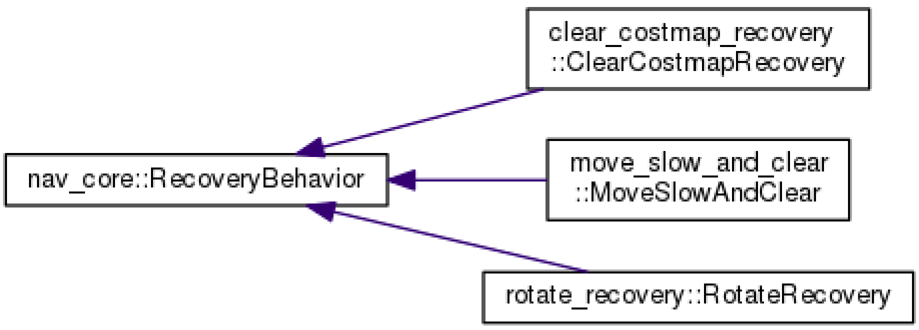


- conservative reset： Recover conservatively.
- clearing rotation： Rotate to clear.
- aggressive reset： Actively recover.
- aborted： Aborted.

2) Related feature packs

In the navigation function package set, there are 3 packages related to the recovery mechanism. They are: clear_costmap_recovery, move_slow_and_clear, rotate_recovery.

Three classes are defined in these three packages, all of which inherit the interface specifications in nav_core.



4、costmap_params

The navigation function uses two cost maps to store obstacle information.

7.4.1、costmap_common

Cost map public parameter configuration costmap_common_params.yaml

```
obstacle_range: 2.5
raytrace_range: 3.0
footprint: [[x0, y0], [x1, y1], ... [xn, yn]]
# robot_radius: ir_of_robot
inflation_radius: 0.55

observation_sources: laser_scan_sensor point_cloud_sensor

laser_scan_sensor: {sensor_frame: frame_name, data_type: LaserScan, topic:
topic_name, marking: true, clearing: true}

point_cloud_sensor: {sensor_frame: frame_name, data_type: PointCloud, topic:
topic_name, marking: true, clearing: true}
```

7.4.2、global_costmap

Global cost map parameter configuration global_costmap_params.yaml

```
global_costmap:
  global_frame: /map
  robot_base_frame: base_link
  update_frequency: 5.0
  static_map: true
```

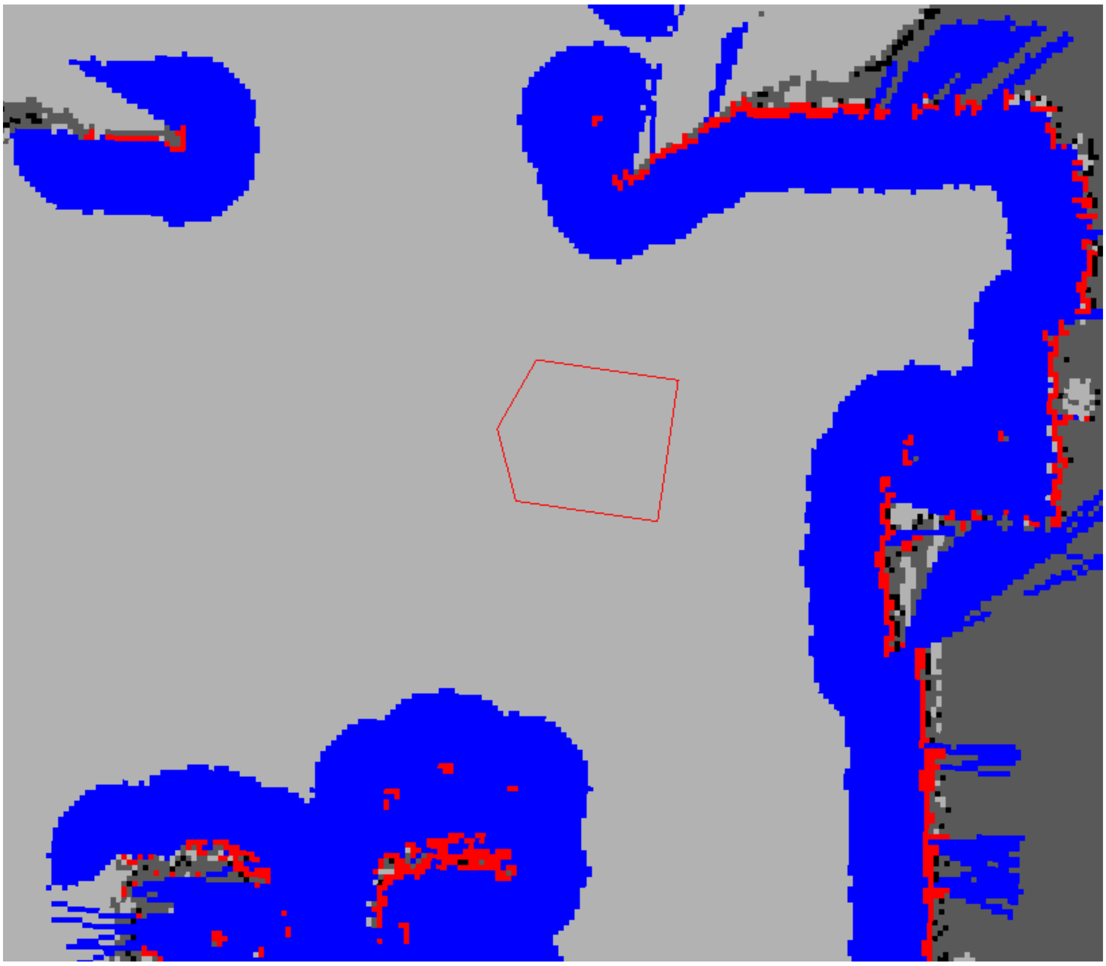
7.4.3、local_costmap

Local cost map parameter configuration local_costmap_params.yaml

```
local_costmap:
  global_frame: odom
  robot_base_frame: base_link
  update_frequency: 5.0
  publish_frequency: 2.0
  static_map: false
  rolling_window: true
  width: 6.0
  height: 6.0
  resolution: 0.05
```

7.4.4、costmap_2D

1) Introduction



- Red represents obstacles in the cost map.
- Blue means that the robot is inscribed with an obstacle with an expanding radius,
- Red polygon represents the footprint of the robot.
- In order for the robot to avoid collisions, the outer shell of the robot must never intersect the red cell, and the center point of the robot must never intersect the blue cell.

7.5、planner_params

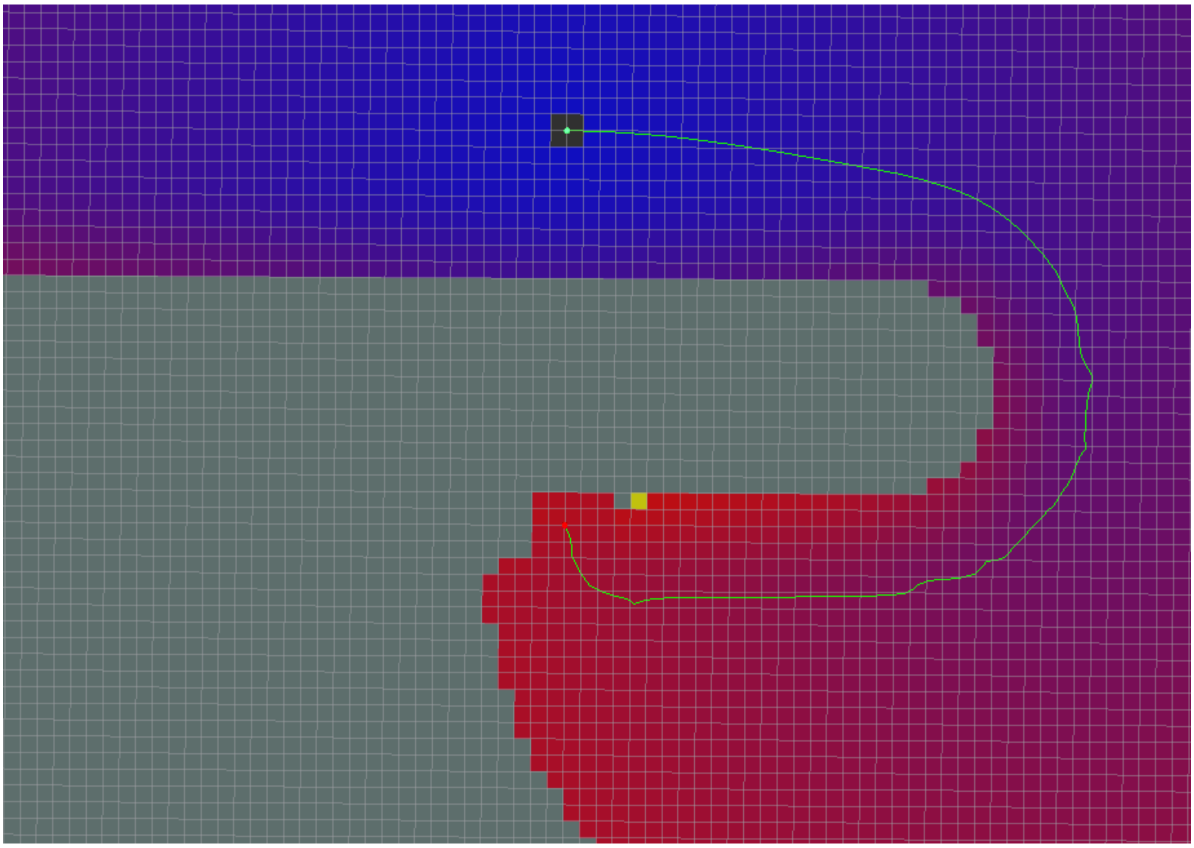
7.5.1、global_planner

global_planner_params.yaml

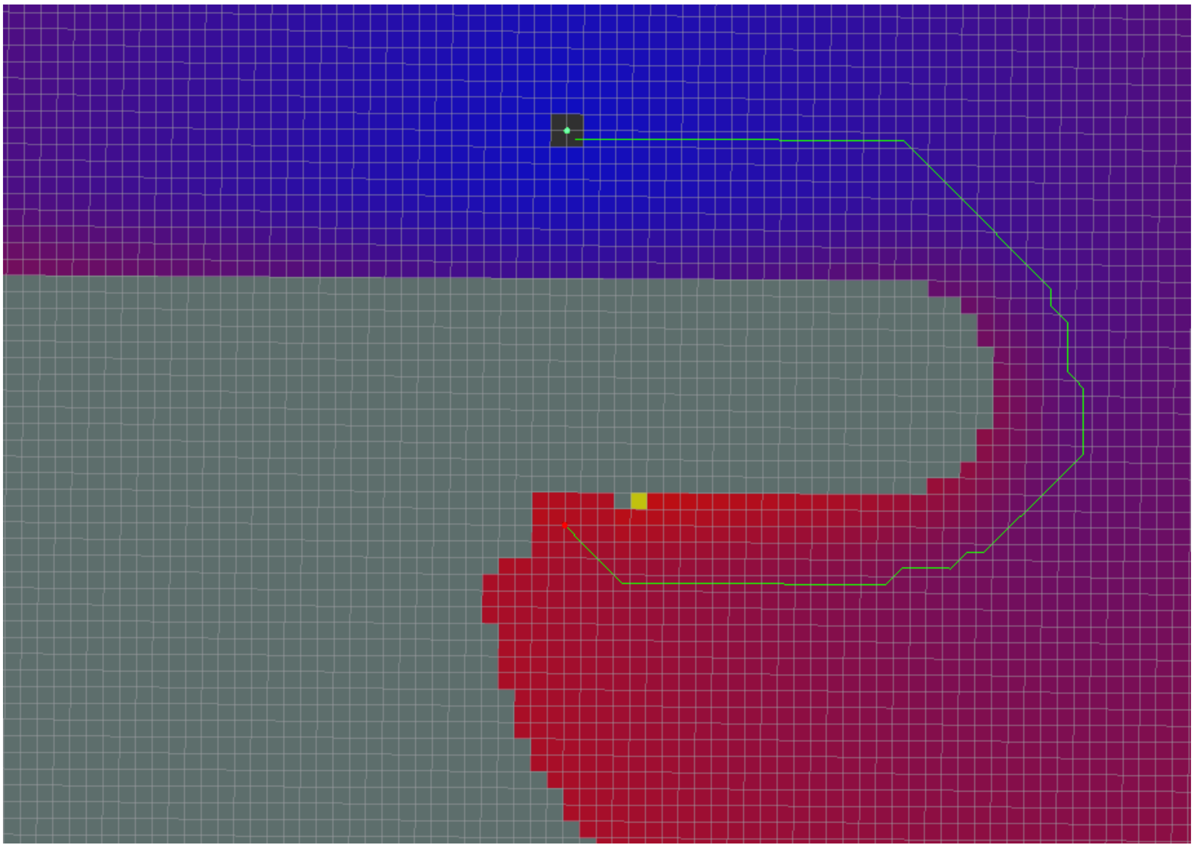
```
GlobalPlanner:
  allow_unknown: false
  default_tolerance: 0.2
  visualize_potential: false
  use_dijkstra: true
  use_quadratic: true
  use_grid_path: false
  old_navfn_behavior: false
  lethal_cost: 253
  neutral_cost: 50
  cost_factor: 3.0
  publish_potential: true
  orientation_mode: 0
  orientation_window_size: 1
```

Global path planning algorithm renderings

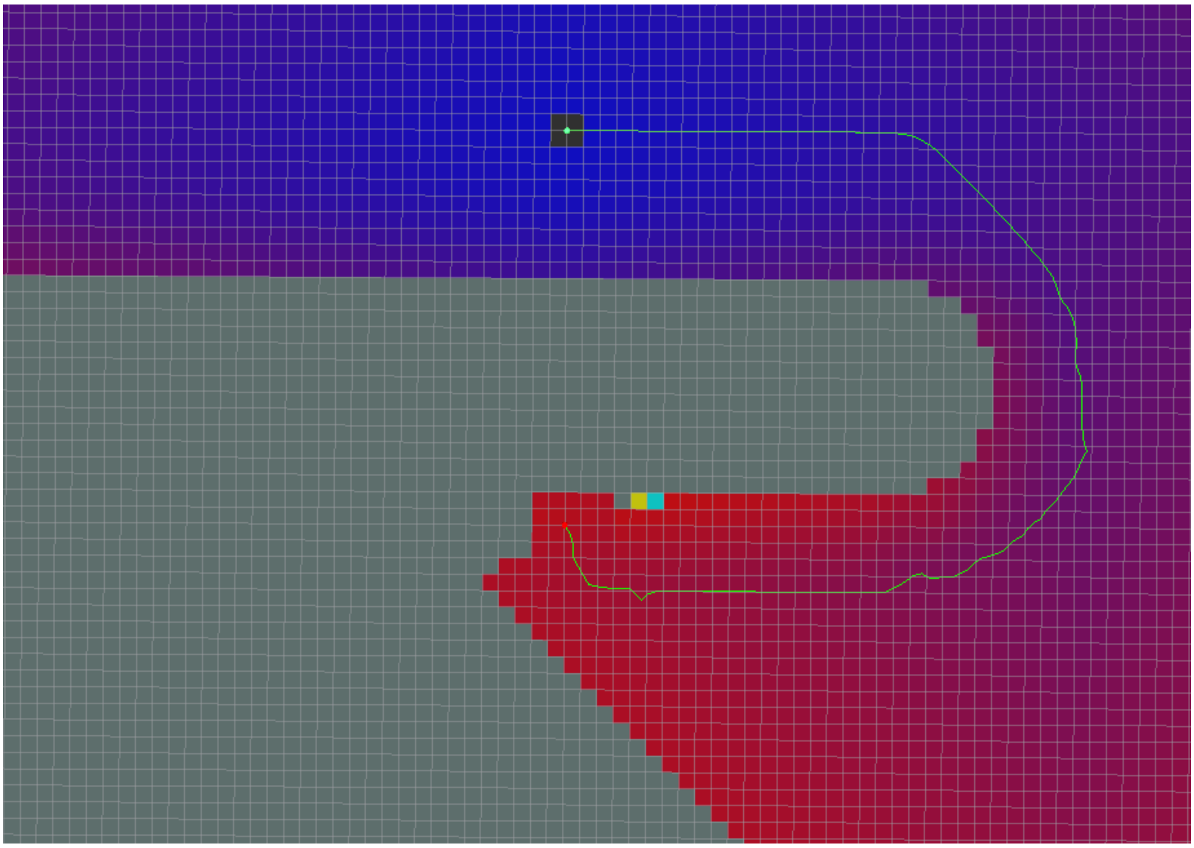
- All parameters are default values



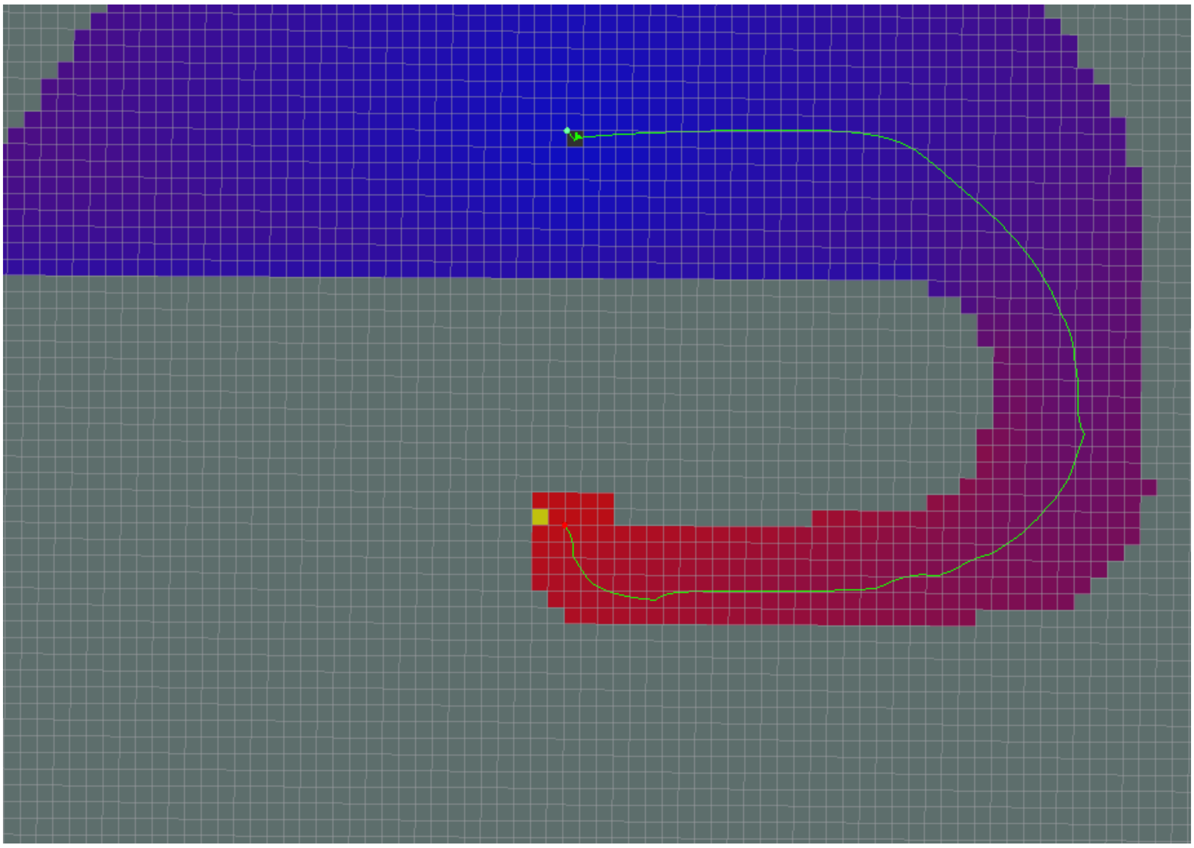
- use_grid_path=True



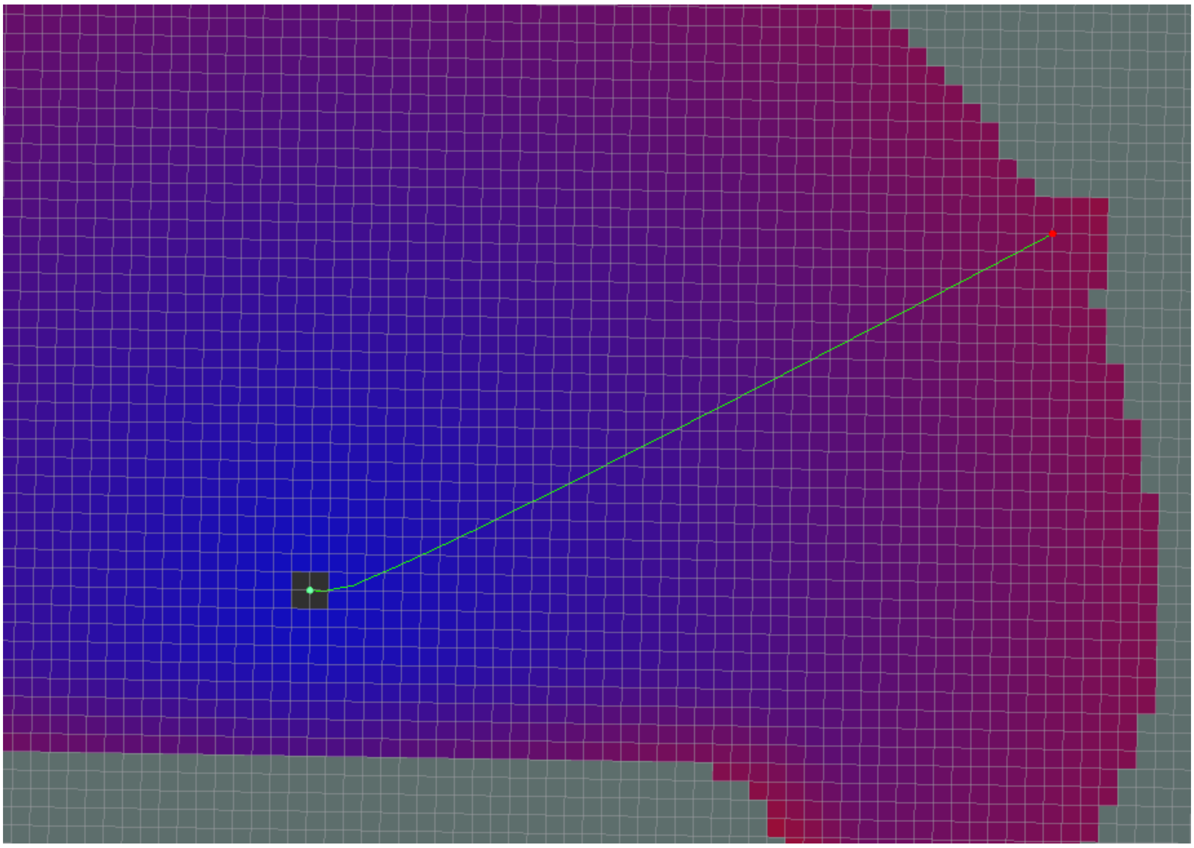
- use_quadratic=False



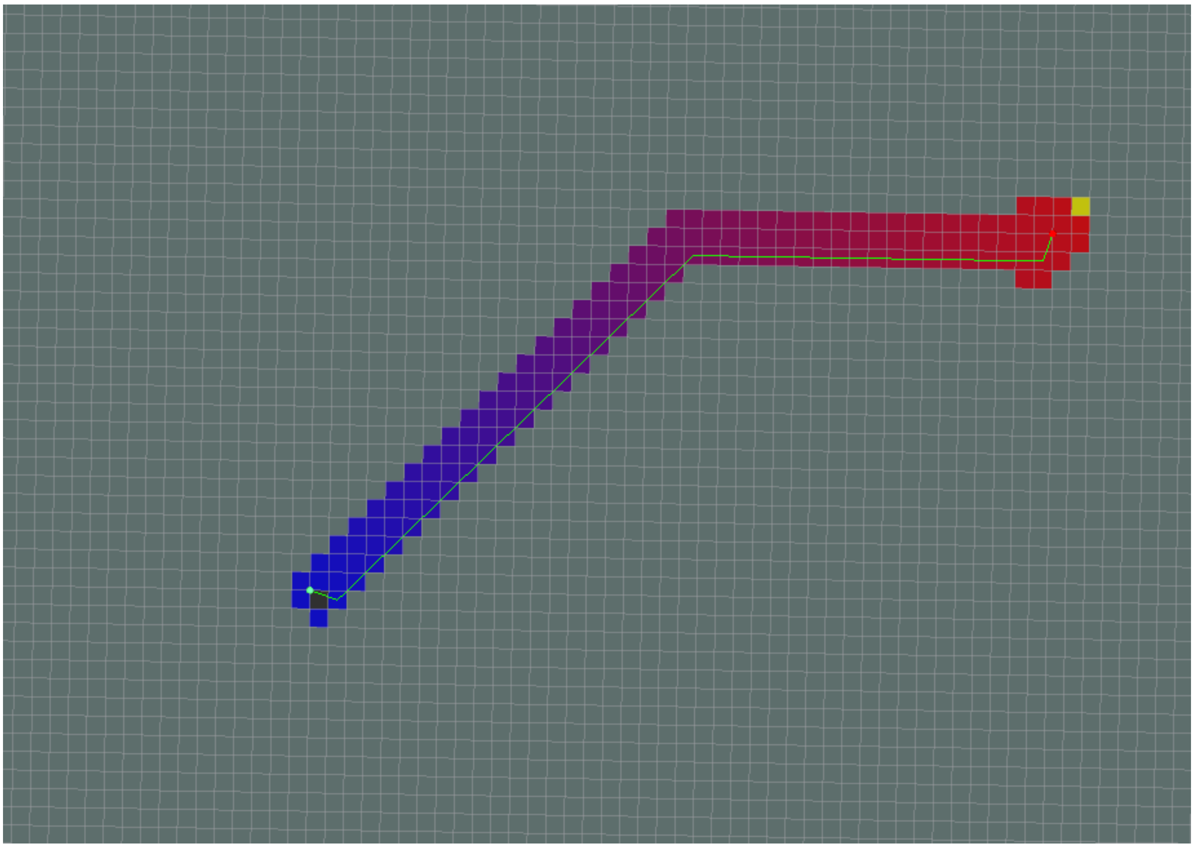
- use_dijkstra=False



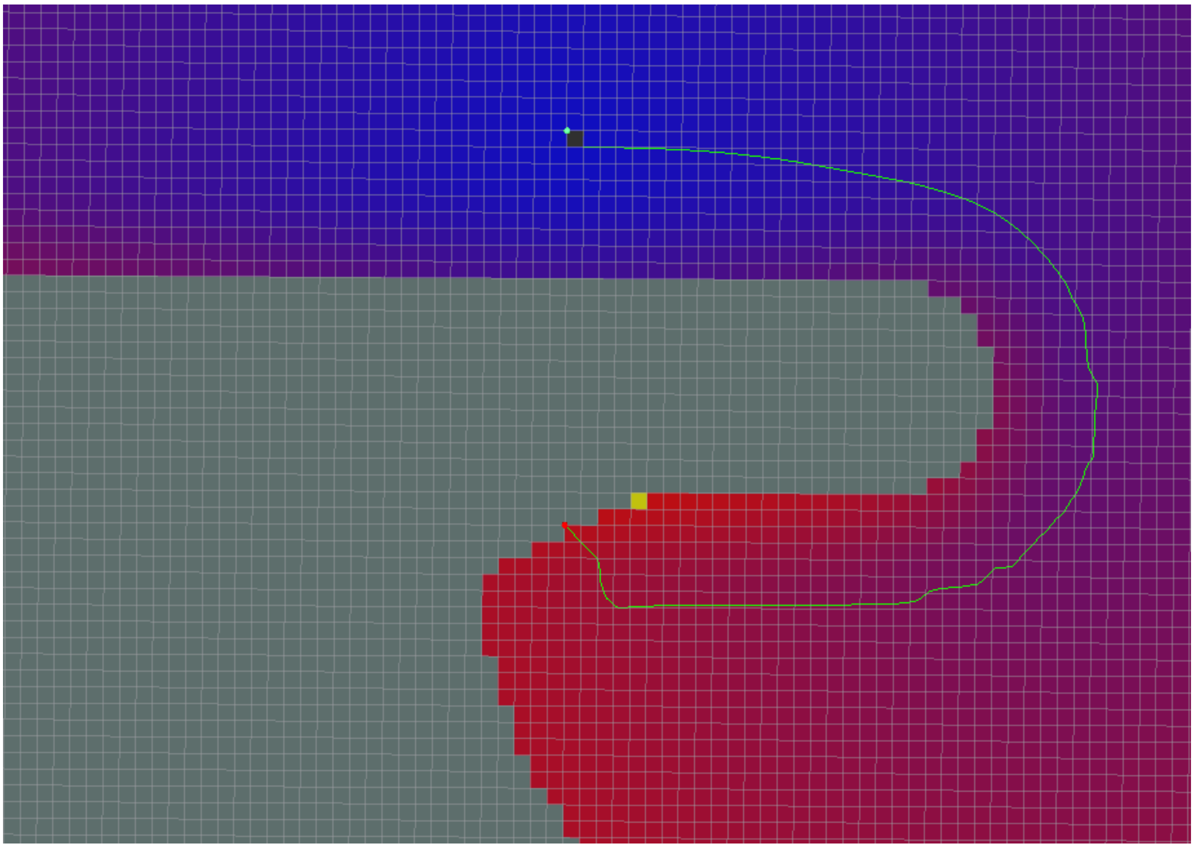
- Dijkstra



- A*



- old_navfn_behavior=True



If it appears at the very beginning:

```
[ERROR] [1611670223.557818434, 295.312000000]: NO PATH!
[ERROR] [1611670223.557951973, 295.312000000]: Failed to get a plan from
potential when a legal potential was found. This shouldn't happen.
```

7.5.2、local_planner

nav_core::BaseLocalPlanner provides an interface for local path planners used in navigation.

```
DWAPlannerROS:
# Robot Configuration Parameters
  acc_lim_x: 2.5
  acc_lim_y: 2.5
  acc_lim_th: 3.2
  max_vel_trans: 0.55
  min_vel_trans: 0.1
  max_vel_x: 0.55
  min_vel_x: 0.0
  max_vel_y: 0.1
  min_vel_y: -0.1
  max_rot_vel: 1.0
  min_rot_vel: 0.4
# Goal Tolerance Parameters
  yaw_goal_tolerance: 0.05
  xy_goal_tolerance: 0.10
  latch_xy_goal_tolerance: false
# Forward Simulation Parameters
  sim_time: 2.0
  sim_granularity: 0.025
```

```
    vx_samples: 6
    vy_samples: 1
    vth_samples: 20
    controller_frequency: 5.0
  # Trajectory Scoring Parameters
    path_distance_bias: 90.0      # 32.0
    goal_distance_bias: 24.0      # 24.0
    occdist_scale: 0.3            # 0.01
    forward_point_distance: 0.325 # 0.325
    stop_time_buffer: 0.2         # 0.2
    scaling_speed: 0.20           # 0.25
    max_scaling_factor: 0.2       # 0.2
    publish_cost_grid: false
  # Oscillation Prevention Parameters
    oscillation_reset_dist: 0.05  # default 0.05
  # Global Plan Parameters
    prune_plan: false
```

teb_local_planner_params.yaml

```
TebLocalPlannerROS:
# Miscellaneous Parameters
 map_frame: odom
 odom_topic: odom
# Robot
 acc_lim_x: 0.5
 acc_lim_theta: 0.5
 max_vel_x: 0.4
 max_vel_x_backwards: 0.2
 max_vel_theta: 0.3
 min_turning_radius: 0.0
 footprint_model:
   type: "point"
# GoalTolerance
 xy_goal_tolerance: 0.2
 yaw_goal_tolerance: 0.1
 free_goal_vel: False
# Trajectory
 dt_ref: 0.3
 dt_hysteresis: 0.1
 min_samples: 3
 global_plan_overwrite_orientation: True
 allow_init_with_backwards_motion: False
 max_global_plan_lookahead_dist: 3.0
 global_plan_viapoint_sep: -1
 global_plan_prune_distance: 1
 exact_arc_length: False
 feasibility_check_no_poses: 5
 publish_feedback: False
# Obstacles
 min_obstacle_dist: 0.25
 inflation_dist: 0.6
 include_costmap_obstacles: True
```

```yaml
  costmap_obstacles_behind_robot_dist: 1.5
  obstacle_poses_affected: 15
  dynamic_obstacle_inflation_dist: 0.6
  include_dynamic_obstacles: True
  costmap_converter_plugin: ""
  costmap_converter_spin_thread: True
  costmap_converter_rate: 5
 # Optimization
  no_inner_iterations: 5
  no_outer_iterations: 4
  optimization_activate: True
  optimization_verbose: False
  penalty_epsilon: 0.1
  obstacle_cost_exponent: 4
  weight_max_vel_x: 2
  weight_max_vel_theta: 1
  weight_acc_lim_x: 1
  weight_acc_lim_theta: 1
  weight_kinematics_nh: 1000
  weight_kinematics_forward_drive: 1
  weight_kinematics_turning_radius: 1
  weight_optimaltime: 1 # must be > 0
  weight_shortest_path: 0
  weight_obstacle: 100
  weight_inflation: 0.2
  weight_dynamic_obstacle: 10
  weight_dynamic_obstacle_inflation: 0.2
  weight_viapoint: 1
  weight_adapt_factor: 2
 # Parallel Planning
  enable_homotopy_class_planning: True
  enable_multithreading: True
  max_number_classes: 4
  selection_cost_hysteresis: 1.0
  selection_prefer_initial_plan: 0.9
  selection_obst_cost_scale: 100.0
  selection_alternative_time_cost: False
  roadmap_graph_no_samples: 15
  roadmap_graph_area_width: 5
  roadmap_graph_area_length_scale: 1.0
  h_signature_prescaler: 0.5
  h_signature_threshold: 0.1
  obstacle_heading_threshold: 0.45
  switching_blocking_period: 0.0
  viapoints_all_candidates: True
  delete_detours_backwards: True
  max_ratio_detours_duration_best_duration: 3.0
  visualize_hc_graph: False
  visualize_with_time_as_z_axis_scale: False
 # Recovery
  shrink_horizon_backup: True
  shrink_horizon_min_duration: 10
  oscillation_recovery: True
  oscillation_v_eps: 0.1
  oscillation_omega_eps: 0.1
```

```
oscillation_recovery_min_duration: 10
oscillation_filter_duration: 10
```

7.6、AMCL

7.6.1、Introduction

Adaptive Monte Carlo localization is a probabilistic positioning system for two-dimensional mobile robots.