一、Gazebo仿真环境搭建

1.1 创建一个工作空间或打开一个现成的工作空间

1.2 在workspace/src下创建gazebo_pkg功能包

- 打开一个终端（Ctrl + Alt + T），输入以下命令

```
cd workspace/src                #进入代码目录

catkin_create_pkg gazebo_pkg     #创建功能包

cd ..                           #返回上级目录

catkin_make                     #编译
```

1.3 将材料中的urdf、world、meshes文件夹复制到gazebo_pkg功能包下

urdf、meshes文件夹中存放的是机器人的模型文件

world文件夹存放的是Gezebo的世界模型文件

1.4 创建launch启动文件

- 在gazebo_pkg功能包下创建launch文件夹
- 在launch文件夹下创建race.launch文件
- 将以下代码复制至race.launch文件中

```
<launch>
  <!-- these are the arguments you can pass this launch file, for example paused:=true -->
  <arg name="paused" default="true"/>
<!--   <arg name="use_sim_time" default="true"/> -->
  <arg name="gui" default="true"/>
  <arg name="headless" default="false"/>
  <arg name="debug" default="false"/>
  <!-- <remap from="robot/laser/scan" to="/scan"/> -->

  <!--模型车的起点放置位置-->
    <arg name="x_pos" default="0.18"/>
    <arg name="y_pos" default="0.0"/>
    <arg name="z_pos" default="0.0"/>
    <arg name="R_pos" default="0.0"/>
    <arg name="P_pos" default="0.0"/>
```

```
    <arg name="Y_pos" default="3.1416"/>


  <include file="$(find gazebo_ros)/launch/empty_world.launch">
    <arg name="world_name" value="$(find gazebo_pkg)/world/map_model.world"/>
    <arg name="debug" value="$(arg debug)" />
    <arg name="gui" value="$(arg gui)" />
  </include>

 <!-- Load the URDF into the ROS Parameter Server -->
  <arg name="model" default="$(find gazebo_pkg)/urdf/racecar.xacro" />

  <param name="robot_description" command="$(find xacro)/xacro  --inorder $(arg
model)" />

  <!-- Run a python script to send a service call the gazebo_ros to spawn a URDF
robot -->
  <node name="urdf_spawner" pkg="gazebo_ros" type="spawn_model" respawn="false"
output="screen"
    args="-urdf -model racecar -param robot_description -x $(arg x_pos) -y $(arg
y_pos) -z $(arg z_pos) -R $(arg R_pos) -P $(arg P_pos) -Y $(arg Y_pos)"/>


  <!-- ros_control racecar launch file -->
  <!--<include file="$(find racecar_control)/launch/racecar_control.launch"
ns="/"/>-->

  <!--Launch the simulation joystick control -->
  <!--<rosparam command="load" file="$(find
racecar_control)/config/keyboard_teleop.yaml" />
  <node pkg="racecar_control" type="keyboard_teleop.py" name="keyboard_teleop"
/>  -->

  <node name="joint_state_publisher" pkg="joint_state_publisher"
type="joint_state_publisher" />
  <node name="robot_state_publisher" pkg="robot_state_publisher"
type="robot_state_publisher"/>

</launch>
```

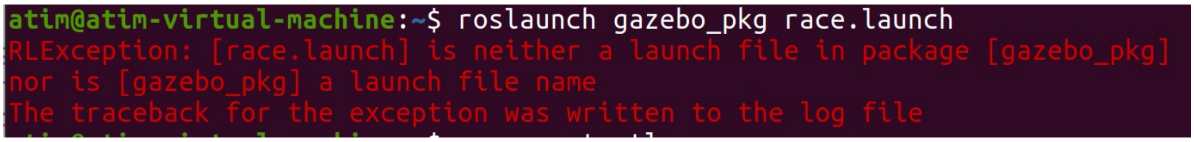
1.5 将路径添加进.bashrc文件中

Ubuntu默认使用的终端是bash，就是（Ctrl + Alt + T）召唤出来的黑框框，**bash 在每次启动时都会加载 .bashrc 文件的内容**，.bashrc文件的作用是用来**存储并加载你的终端配置和环境变量。**

例如，ROS默认安装在/opt路径下的，我们来看看.bashrc文件中是如何帮我们找到ROS的；.bashrc文件**位于主目录下**，并且是隐藏文件，打开你的主目录，按 **（Ctrl + H）** 恢复隐藏文件，你就可以看到.bashrc文件，如果你已经成功地将小乌龟跑起来了，就可以在最后一行看到

```
source /opt/ros/ros版本/setup.bash
```

同理，想要运行自己的程序，也要告诉bash你自己的文件路径，否则的话，当你想要运行launch文件或执行rosrun命令时，就会**报找不到文件路径的错误**：



而添加环境有以下两种方法：

1. 打开一个终端，进入你的**workspace目录下**，运行

   ```
   source devel/setup.bash
   ```

   此时再次运行roslaunch、rosrun等命令即可正常运行，但这种办法每次重新打开一个终端、添加新的功能包及进行编译都要再次运行，所以下面介绍另一种方法：

2. 手动添加命令到.bashrc

- 打开终端输入：

  ```
  gedit ~/.bashrc
  ```

  打开.bashrc文件，当然你也可以在主目录（home）下唤出隐藏文件**（Ctrl + H）**，直接打开.bashrc文件

- 在.bashrc文件最后一行添加命令：

  ```
  source ~/workspace/devel/setup.bash
  # workspace 为你自己工作空间的名字
  ```

- 在终端输入：

  ```
  source ~/.bashrc
  ```

  使环境变量生效

  - 前两步也可以用以下命令替代：

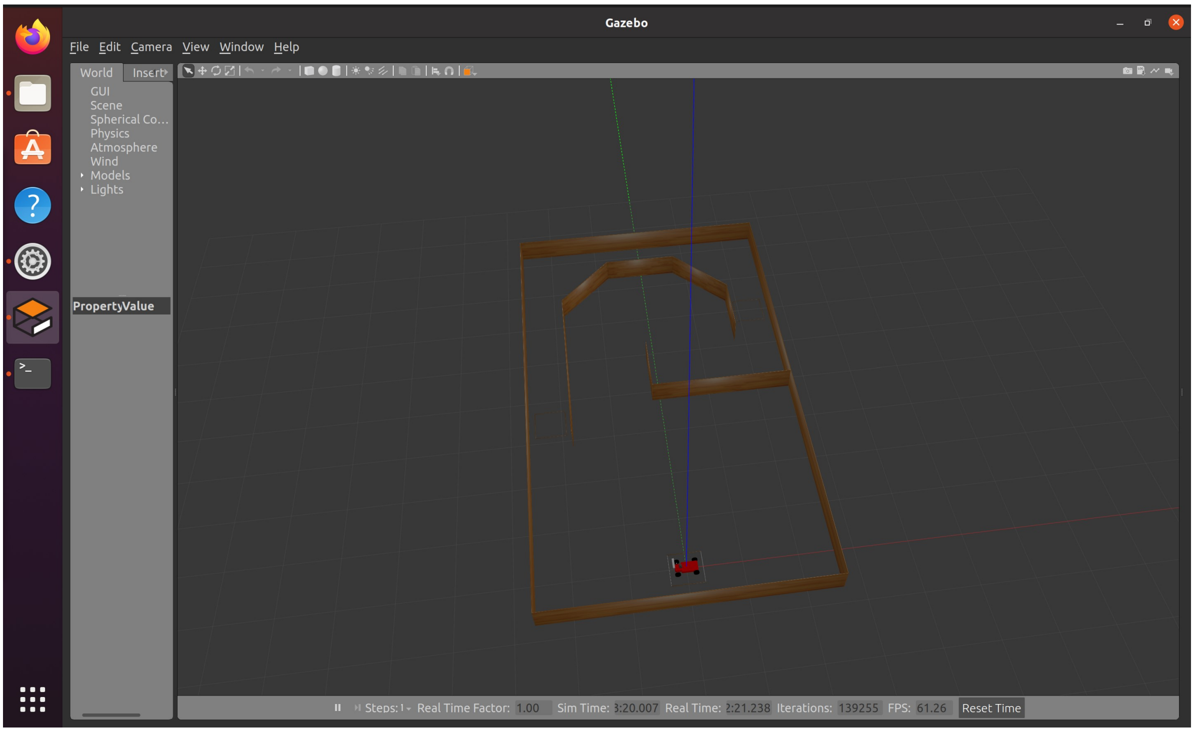
    ```
    echo "source ~/catkin_ws/devel/setup.sh" >> ~/.bashrc
    ```

1.6 运行Gazebo仿真环境

打开终端，运行：

```
roslaunch gazebo_pkg race.launch
```

如果前面的步骤都没有问题，那么**恭喜你！**你已经成功运行起Gazebo的仿真环境了，你将会看到以下的画面：



1.7 控制机器人运动

在安装ROS时，相信你已经体验过了怎么使用键盘来控制小乌龟来进行运动；同样的，我们也可以使用键盘来控制我们自己的机器人进行运动，为后面的建图做准备：

- 安装依赖，终端中输入：

```
sudo apt-get install ros-版本-effort-controllers
sudo apt-get install ros-版本-ackermann-msgs
```

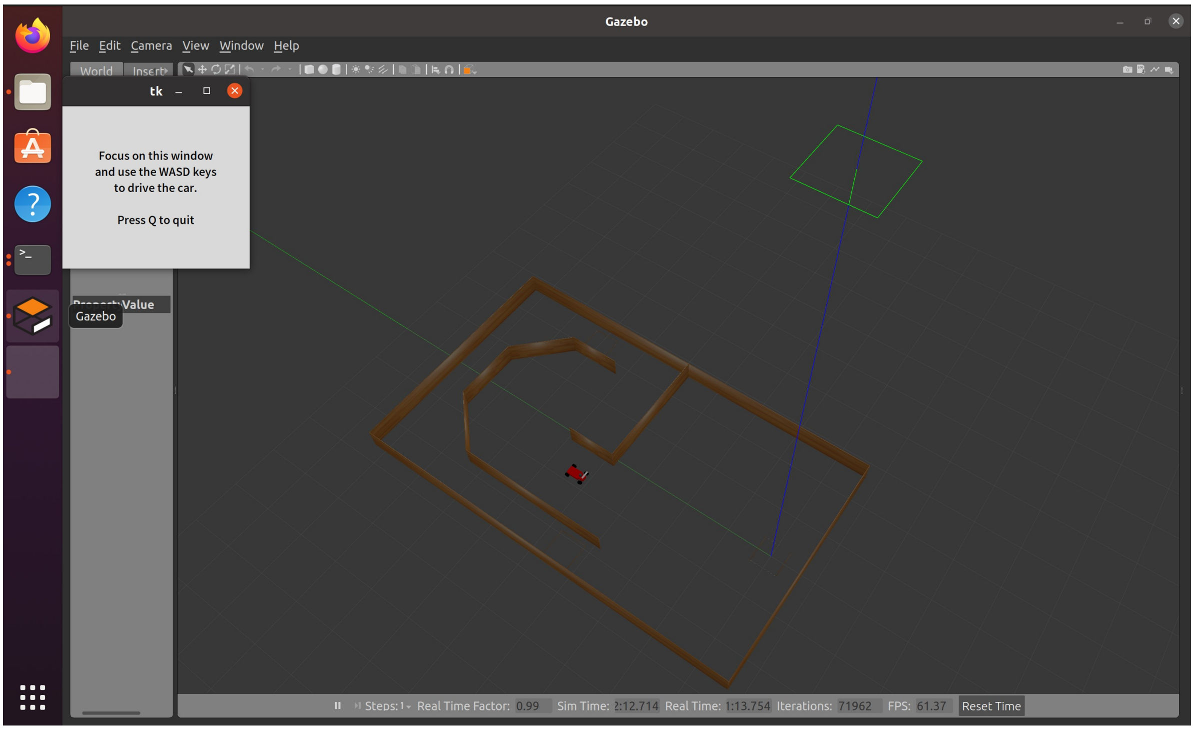
- 将**材料中**的racecar_control功能包复制至workspace/src下
- 进行编译：

```
cd workspace

catkin_make
```

- 打开终端运行：

```
roslaunch gazebo_pkg race.launch

roslaunch racecar_control racecar_control.launch
```

- 此时你已经可以控制机器人进行运动啦！试试控制它跑一圈叭



二、建图功能包创建

在Linux平台下，软件包的类型可以划分为两类：源码包、二进制包；

一个软件要在Linux上执行，必须是二进制文件；

源码包：即程序软件的源代码（一般也叫Tarball，即将软件的源码以tar打包后再压缩的资源包）；源码包是作者直接将源程序发布在网上，我们直接下载源文件，自己编译成二进制程序使用；

二进制包：如 Red Hat发行版的.rpm包，Debian发行版的.deb包；我们可以在ROS的安装路径/opt下找到各个依赖包对应的库文件(lib)、头文件(include)、可执行文件等

区别	二进制包	源代码
下载方式	apt-get install /下载deb	git clone/github等网站直接下载源码
编译方式	无需编译	通过make/cmake/catkin
来源	官方apt软件源	开源项目/第三方开发者
扩展性	无法修改	通过源代码修改
可读性	无法查看源代码	方便阅读、学习源代码
优点	下载简单、安装方便	源码可修改、卸载
缺点	无法修改	安装、编译复杂

- ros中当我们没有学习、修改功能包源码的需求时，我们可以选择二进制安装
- 一般我们只需配置好必要的参数即可使用功能包

2.1 在workspace/src下创建gazebo_map功能包

- 打开终端，输入：

```
cd workspace/src                  #进入代码目录

catkin_create_pkg gazebo_map      #创建功能包

cd ..                             #返回上级目录

catkin_make                       #编译
```

2.2 在gazebo_map功能包下创建cfg、launch、map三个文件夹

cfg文件夹存放的是参数配置文件

launch文件夹存放的是建图节点启动文件

map文件夹存放的是建图完成后的地图图片(.pgm)和配置文件(.yaml)

2.3 安装建图功能包

这里给出几种slam方法的源码地址可供学习、安装：

- **激光SLAM**：
    - **gmapping**：https://github.com/ros-perception/openslam_gmapping
      https://github.com/ros-perception/slam_gmapping.git
    - **hector**：https://github.com/tu-darmstadt-ros-pkg/hector_slam
    - **karto**：https://github.com/ros-perception/open_karto.git
      https://github.com/ros-perception/slam_karto.git
    - **cartographer**：https://github.com/googlecartographer/cartographer.git
      https://github.com/googlecartographer/cartographer_ros.git
    - **LOAM**：https://github.com/laboshinl/loam_velodyne.git
- **视觉SLAM**：
    - **ORB_SLAM**：https://github.com/raulmur/ORB_SLAM
      https://github.com/raulmur/ORB_SLAM2
      https://github.com/UZ-SLAMLab/ORB_SLAM3.git
    - **LSD_SLAM**：https://github.com/tum-vision/lsd_slam （https://github.com/zouyuelin/LSD_SLAM_Changed.git
- **其它**：
    - **RTABMAP**：https://github.com/introlab/rtabmap_ros
    - **VINS**：https://github.com/HKUST-Aerial-Robotics/VINS-Mono.git

你可以在以下几种方法中任选其一，也可都安装，它们并不冲突，甚至你可以比较用以下几种方法建立的地图谁更好。当你完成**2.3.x**中的任意一个你就可以跳到**2.4**开始建图啦！

2.3.1 gmapping安装

- 采用二进制安装，终端中输入：

```
sudo apt-get install ros-版本-slam-gmapping
sudo apt-get install ros-版本-gmapping
```

- 于launch文件夹中创建slam_gmapping.launch文件
- 将以下代码复制至slam_gmapping.launch文件中

```
<launch>
    <param name="use_sim_time" value="true"/>
    <node pkg="gmapping" type="slam_gmapping" name="slam_gmapping"
output="screen">
      <remap from="scan" to="scan"/>
      <param name="base_frame" value="base_link"/>
      <param name="map_frame" value="map"/>
      <param name="odom_frame" value="odom"/>

      <param name="map_update_interval" value="5.0"/>
      <param name="maxUrange" value="16.0"/>
      <param name="sigma" value="0.05"/>
      <param name="kernelSize" value="1"/>
      <param name="lstep" value="0.05"/>
      <param name="astep" value="0.05"/>
      <param name="iterations" value="5"/>
      <param name="lsigma" value="0.075"/>
      <param name="ogain" value="3.0"/>
      <param name="lskip" value="0"/>
      <param name="srr" value="0.1"/>
      <param name="srt" value="0.2"/>
      <param name="str" value="0.1"/>
      <param name="stt" value="0.2"/>
      <param name="linearUpdate" value="1.0"/>
      <param name="angularUpdate" value="0.5"/>
      <param name="temporalUpdate" value="3.0"/>
      <param name="resampleThreshold" value="0.5"/>
      <param name="particles" value="30"/>
      <param name="xmin" value="-50.0"/>
      <param name="ymin" value="-50.0"/>
      <param name="xmax" value="50.0"/>
      <param name="ymax" value="50.0"/>
      <param name="delta" value="0.05"/>
      <param name="llsamplerange" value="0.01"/>
      <param name="llsamplestep" value="0.01"/>
      <param name="lasamplerange" value="0.005"/>
      <param name="lasamplestep" value="0.005"/>
    </node>
</launch>
```

2.3.2 hector安装

- 采用二进制安装，终端中输入：

```
sudo apt-get install rod-版本-hector-slam
```

- 于launch文件夹中创建slam_hector文件夹，同时创建slam_hector.launch、mapping_default.launch、geotiff_mapper.launch三个文件
- 将以下代码复制至slam_hector.launch文件中

```
<?xml version="1.0"?>

<launch>

  <arg name="geotiff_map_file_path" default="$(find gazebo_map)/map"/>

  <param name="/use_sim_time" value="true"/>

  <!-- <node pkg="rviz" type="rviz" name="rviz"
    args="-d $(find hector_slam_launch)/rviz_cfg/mapping_demo.rviz"/> -->

  <include file="$(find
gazebo_map)/launch/slam_hector/mapping_default.launch"/>

  <include file="$(find
gazebo_map)/launch/slam_hector/geotiff_mapper.launch">
    <arg name="trajectory_source_frame_name" value="scanmatcher_frame"/>
    <arg name="map_file_path" value="$(arg geotiff_map_file_path)"/>
  </include>

</launch>
```

- 将以下代码复制至mapping_default.launch文件中

```
<?xml version="1.0"?>

<launch>
  <arg name="tf_map_scanmatch_transform_frame_name"
default="scanmatcher_frame"/>
  <arg name="base_frame" default="base_link"/>
  <arg name="odom_frame" default="odom"/>
  <arg name="pub_map_odom_transform" default="true"/>
  <arg name="scan_subscriber_queue_size" default="5"/>
  <arg name="scan_topic" default="scan"/>
  <arg name="map_size" default="2048"/>

  <node pkg="hector_mapping" type="hector_mapping" name="hector_mapping"
output="screen">

    <!-- Frame names -->
    <param name="map_frame" value="map" />
    <param name="base_frame" value="$(arg base_frame)" />
    <param name="odom_frame" value="$(arg odom_frame)" />

    <!-- Tf use -->
```

```
    <param name="use_tf_scan_transformation" value="true"/>
    <param name="use_tf_pose_start_estimate" value="false"/>
    <param name="pub_map_odom_transform" value="$(arg
pub_map_odom_transform)"/>

    <!-- Map size / start point -->
    <param name="map_resolution" value="0.050"/>
    <param name="map_size" value="$(arg map_size)"/>
    <param name="map_start_x" value="0.5"/>
    <param name="map_start_y" value="0.5" />
    <param name="map_multi_res_levels" value="2" />

    <!-- Map update parameters -->
    <param name="update_factor_free" value="0.4"/>
    <param name="update_factor_occupied" value="0.9" />
    <param name="map_update_distance_thresh" value="0.4"/>
    <param name="map_update_angle_thresh" value="0.9" />
    <param name="laser_z_min_value" value = "-1.0" />
    <param name="laser_z_max_value" value = "1.0" />

    <!-- Advertising config -->
    <param name="advertise_map_service" value="true"/>

    <param name="scan_subscriber_queue_size" value="$(arg
scan_subscriber_queue_size)"/>
    <param name="scan_topic" value="$(arg scan_topic)"/>

    <!-- Debug parameters -->
    <!--
      <param name="output_timing" value="false"/>
      <param name="pub_drawings" value="true"/>
      <param name="pub_debug_output" value="true"/>
    -->
    <param name="tf_map_scanmatch_transform_frame_name" value="$(arg
tf_map_scanmatch_transform_frame_name)" />
  </node>

  <!-- <node pkg="tf" type="static_transform_publisher"
name="map_odom_broadcaster" args="0 0 0 0 0 0 map $(arg odom_frame) 100"/> -
->
</launch>
```

- 将以下代码复制至geotiff_mapper.launch文件中

```
<?xml version="1.0"?>

<launch>
  <arg name="trajectory_source_frame_name" default="/base_link"/>
  <arg name="trajectory_update_rate" default="4"/>
  <arg name="trajectory_publish_rate" default="0.25"/>
  <arg name="map_file_path" default="$(find gazebo_map)/map"/>
  <arg name="map_file_base_name" default="hector_map"/>

  <node pkg="hector_trajectory_server" type="hector_trajectory_server"
name="hector_trajectory_server" output="screen">
    <param name="target_frame_name" type="string" value="/map" />
```

```
    <param name="source_frame_name" type="string" value="$(arg
trajectory_source_frame_name)" />
    <param name="trajectory_update_rate" type="double" value="$(arg
trajectory_update_rate)" />
    <param name="trajectory_publish_rate" type="double" value="$(arg
trajectory_publish_rate)" />
  </node>

  <node pkg="hector_geotiff" type="geotiff_node" name="hector_geotiff_node"
output="screen" launch-prefix="nice -n 15">
    <remap from="map" to="/dynamic_map" />
    <param name="map_file_path" type="string" value="$(arg map_file_path)"
/>
    <param name="map_file_base_name" type="string" value="$(arg
map_file_base_name)" />
    <param name="geotiff_save_period" type="double" value="0" />
    <param name="draw_background_checkerboard" type="bool" value="true" />
    <param name="draw_free_space_grid" type="bool" value="true" />
    <param name="plugins" type="string"
value="hector_geotiff_plugins/TrajectoryMapWriter" />
  </node>

</launch>
```

2.3.3 karto安装

- 采用二进制安装，终端中输入：

```
sudo apt-get install ros-版本-slam-karto
```

- 于launch文件夹中创建slam_karto.launch文件
- 将以下代码复制至slam_karto.launch文件中

```
<launch>
    <node pkg = "slam_karto" type = "slam_karto" name = "slam_karto" output
= "screen" >
        <!-- <remap from = "scan" to = "scan"/> -->
        <param name = "odom_frame" value = "odom"/>
        <param name="base_frame" value="base_link"/>
        <param name="map_frame" value="map">
        <param name = "map_update_interval" value = "25"/>
        <param name = "resolution" value = "0.025"/>
    </node>
</launch>
```

2.3.4 cartographer安装

1. **安装依赖**
    - 终端中输入：

    ```
    sudo apt-get install -y \
    ```

```
    cmake \
    g++ \
    git \
    google-mock \
    libboost-all-dev \
    libcairo2-dev \
    libeigen3-dev \
    libgflags-dev \
    libgoogle-glog-dev \
    liblua5.2-dev \
    libsuitesparse-dev \
    libwebp-dev \
    ninja-build \
    protobuf-compiler \
    python3-sphinx \
    libgmock-dev \
    stow
```

2. **修复rosdep**

   通过rosdep install命令可以给当前工作空间自动安装依赖，后面我们将使用它来帮助我们安装ceres库

   当然，如果你在安装ROS时已经解决了rosdep的问题，你便可以跳过这一步了

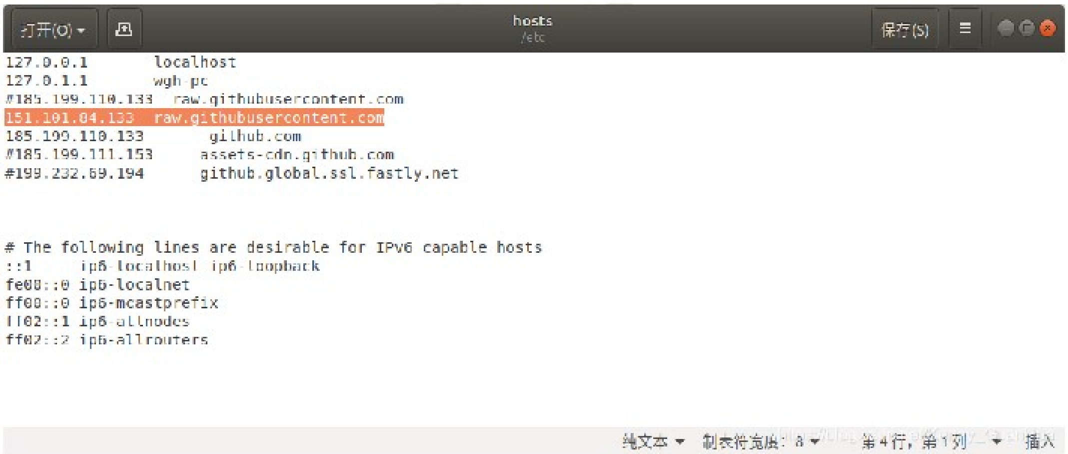
   参考链接：[rosdep update 超时失败2021最新解决方法]()

   常规的方法是修改"/etc/hosts"文件，把"raw.githubusercontent.com"服务器的 ip 地址注册到里边，之前的话，通过此方法基本能解决 rosdep 问题，基本百试百灵。"raw.githubusercontent.com"的服务器 ip 可能会变化，大家可以通过https://www.ipaddress.com这个网站来查询当前的 ip。

   - 终端中输入：

     ```
     sudo gedit /etc/hosts
     ```

   - 根据你查到的ip输入：

   - 终端运行：

     ```
     sudo rosdep init
     rosdep update
     ```

如果还是不行，尝试参考链接中的第二个方法

或尝试使用“rosdepc”：[本文之后，世上再无rosdep更新失败问题！]

看到如下画面则你的rosdep修复成功啦!

```
reading in sources list data from /etc/ros/rosdep/sources.list.d
Warning: running 'rosdep update' as root is not recommended.
  You should run 'sudo rosdep fix-permissions' and invoke 'rosdep update' again without sudo.
Hit https://mirrors.tuna.tsinghua.edu.cn/github-raw/ros/rosdistro/master/rosdep/osx-homebrew.yaml
Hit https://mirrors.tuna.tsinghua.edu.cn/github-raw/ros/rosdistro/master/rosdep/base.yaml
Hit https://mirrors.tuna.tsinghua.edu.cn/github-raw/ros/rosdistro/master/rosdep/python.yaml
Hit https://mirrors.tuna.tsinghua.edu.cn/github-raw/ros/rosdistro/master/rosdep/ruby.yaml
Query rosdistro index https://mirrors.tuna.tsinghua.edu.cn/rosdistro/index-v4.yaml
Skip end-of-life distro "ardent"
Skip end-of-life distro "bouncy"
Skip end-of-life distro "crystal"
Skip end-of-life distro "dashing"
Skip end-of-life distro "eloquent"
Add distro "foxy"
Add distro "galactic"
Skip end-of-life distro "groovy"
Add distro "humble"
Skip end-of-life distro "hydro"
Skip end-of-life distro "indigo"
Skip end-of-life distro "jade"
Skip end-of-life distro "kinetic"
Skip end-of-life distro "lunar"
Add distro "melodic"
Add distro "noetic"
Add distro "rolling"
updated cache in /root/.ros/rosdep/sources.cache
```

3. **安装protobuf3.6.0**

   参考链接：[Cartographer安装教程及踩坑实录]

   - 安装protobuf依赖，终端输入：

     ```
     sudo apt-get install autoconf automake libtool curl make g++ unzip
     ```

   - 克隆源码，终端输入：

     ```
     git clone -b v3.6.0 https://github.com/protocolbuffers/protobuf.git

     cd protobuf

     git submodule update --init --recursive
     ```

   - 编译安装，终端输入：

     ```
     ./autogen.sh

     ./configure

     make //此处编译会很长时间，耐心等待

     make check

     sudo make install

     sudo ldconfig

     // 输出 protobuf 版本信息则表示安装成功
     protoc --version
     ```

   - 查看安装位置，终端输入：

```
which protoc
```

- 如果不是"/usr/bin/protoc"需要更正安装位置，终端输入：

```
sudo cp /usr/local/bin/protoc /usr/bin
```

4. **安装abseil-cpp**
   - 终端依次输入：

```
git clone https://github.com/abseil/abseil-cpp.git

cd abseil-cpp

mkdir build

cd build

cmake -G Ninja \
-DCMAKE_BUILD_TYPE=Release \
-DCMAKE_POSITION_INDEPENDENT_CODE=ON \
-DCMAKE_INSTALL_PREFIX=/usr/local/stow/absl \
..

ninja //编译需要一定时间

sudo ninja install

cd /usr/local/stow

sudo stow absl
```

5. **安装ceres**

   我们这里选择在最后使用rosdep进行二进制安装，当然你也可以选择源码安装，注意是**1.14版本！1.14版本！1.14版本！**

   手动安装参考链接：Ubuntu20.04安装Ceres和g2o库

   Ceres Solver官方教程

6. **编译安装cartographer与cartographer_ros**
   - 安装依赖，终端输入：

```
sudo apt-get install -y python3-wstool python3-rosdep ninja-build stow
```

   - 源码下载，终端输入：

```
git clone https://github.com/googlecartographer/cartographer.git

git clone https://github.com/googlecartographer/cartographer_ros.git
```

   - 终端输入：

```
mkdir cartographer_ws

cd cartographer_ws

wstool init src
```

- 将 cartographer_ros 文件夹放入刚刚创建好的工作空间 src 中
- rosdep 自动安装依赖，仔细可以看到有安装 ceres1.14，终端输入：

```
sudo rosdep init

rosdep update

rosdep install --from-paths src --ignore-src --rosdistro=${ROS_DISTRO} -y
```

- 编译 cartographer，返回主目录，终端输入：

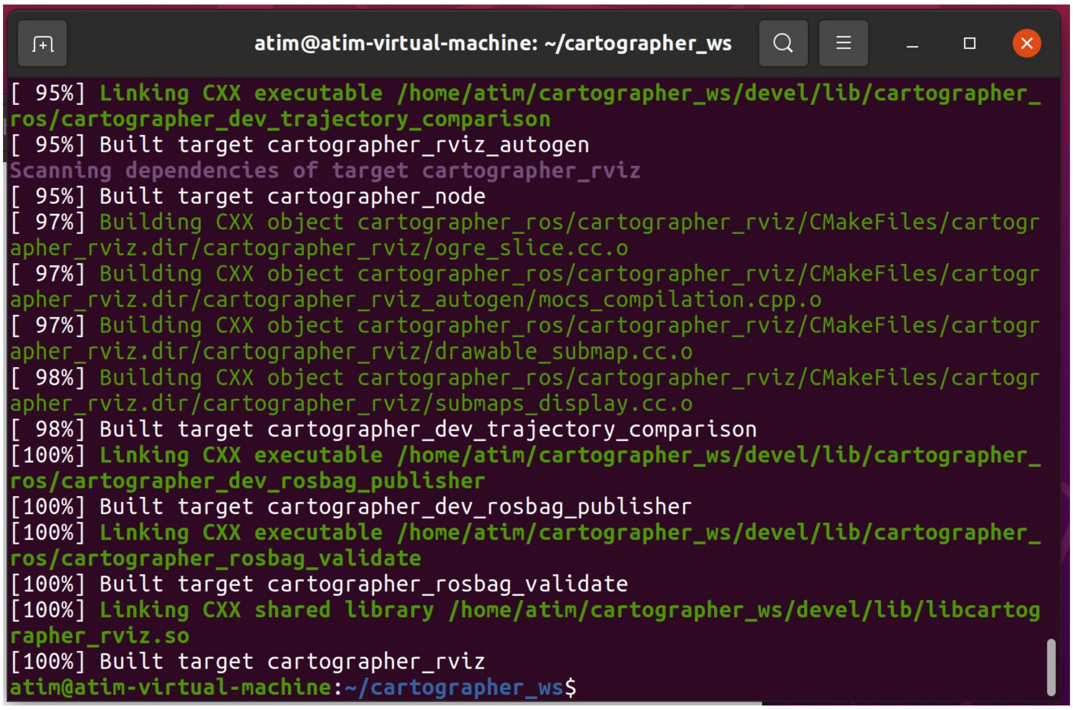
```
cd cartographer

mkdir build

cd build

cmake .. -G Ninja

ninja //编译需要一定时间，耐心等待

CTEST_OUTPUT_ON_FAILURE=1 ninja test

sudo ninja install
```

  编译过程中完全无报错无异常证明已将 cartographer 成功安装到系统中，报错的需要看看问题是不是 protocbuf 版本不对，或者是 ceres 版本不对，查看方法就是直接看报错的文件路径。

- 编译工作空间，回到cartographer_ws 工作空间目录下运行：

```
catkin_make
```

  看到如下画面，**恭喜你！** cartographer安装完成



7. **配置参数配置、节点启动文件**

- **将cartographer_ros功能包复制至你的工作空间src目录下**，并编译：

```
cd workspace

catkin_make
```

- 于cfg文件夹中创建my_revo_lds.lua文件
- 将以下代码复制至my_revo_lds.lua文件中

```
-- Copyright 2016 The Cartographer Authors
--
-- Licensed under the Apache License, Version 2.0 (the "License");
-- you may not use this file except in compliance with the License.
-- You may obtain a copy of the License at
--
--      http://www.apache.org/licenses/LICENSE-2.0
--
-- Unless required by applicable law or agreed to in writing, software
-- distributed under the License is distributed on an "AS IS" BASIS,
-- WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or
implied.
-- See the License for the specific language governing permissions and
-- limitations under the License.

include "map_builder.lua"
include "trajectory_builder.lua"

options = {
  map_builder = MAP_BUILDER,
  trajectory_builder = TRAJECTORY_BUILDER,
  map_frame = "map",
  tracking_frame = "base_link",
  published_frame = "base_link",
  odom_frame = "odom",
  provide_odom_frame = true,
```

```
  publish_frame_projected_to_2d = false,
  use_pose_extrapolator = true,
  use_odometry = false,
  use_nav_sat = false,
  use_landmarks = false,
  num_laser_scans = 1,
  num_multi_echo_laser_scans = 0,
  num_subdivisions_per_laser_scan = 1,
  num_point_clouds = 0,
  lookup_transform_timeout_sec = 0.2,
  submap_publish_period_sec = 0.3,
  pose_publish_period_sec = 5e-3,
  trajectory_publish_period_sec = 30e-3,
  rangefinder_sampling_ratio = 1.,
  odometry_sampling_ratio = 1.,
  fixed_frame_pose_sampling_ratio = 1.,
  imu_sampling_ratio = 1.,
  landmarks_sampling_ratio = 1.,
}

MAP_BUILDER.use_trajectory_builder_2d = true

TRAJECTORY_BUILDER_2D.submaps.num_range_data = 35
TRAJECTORY_BUILDER_2D.min_range = 0.3
TRAJECTORY_BUILDER_2D.max_range = 8.
TRAJECTORY_BUILDER_2D.missing_data_ray_length = 1.
TRAJECTORY_BUILDER_2D.use_imu_data = false
TRAJECTORY_BUILDER_2D.use_online_correlative_scan_matching = true
TRAJECTORY_BUILDER_2D.real_time_correlative_scan_matcher.linear_search_window = 0.1
TRAJECTORY_BUILDER_2D.real_time_correlative_scan_matcher.translation_delta_cost_weight = 10.
TRAJECTORY_BUILDER_2D.real_time_correlative_scan_matcher.rotation_delta_cost_weight = 1e-1

POSE_GRAPH.optimization_problem.huber_scale = 1e2
POSE_GRAPH.optimize_every_n_nodes = 35
POSE_GRAPH.constraint_builder.min_score = 0.65

return options
```

- 于launch文件夹中创建slam_cartographer.launch文件
- 将以下代码复制至slam_cartographer.launch文件中

```
<launch>
  <param name="/use_sim_time" value="true" />

  <node name="cartographer_node" pkg="cartographer_ros"
      type="cartographer_node" args="
          -configuration_directory $(find gazebo_map)/cfg
          -configuration_basename my_revo_lds.lua"
      output="screen">
    <remap from="scan" to="scan" />
  </node>

  <node name="cartographer_occupancy_grid_node" pkg="cartographer_ros"
```

```
        type="cartographer_occupancy_grid_node" args="-resolution 0.05" />

    <!-- <node name="rviz" pkg="rviz" type="rviz" required="true"
        args="-d $(find gazebo_with_map)/cfg/demo.rviz" /> -->
</launch>
```

2.4 开始建图

1. **保存Rviz配置**
    - 于终端中依次打开以下节点启动文件（**这里以gmapping为例**）

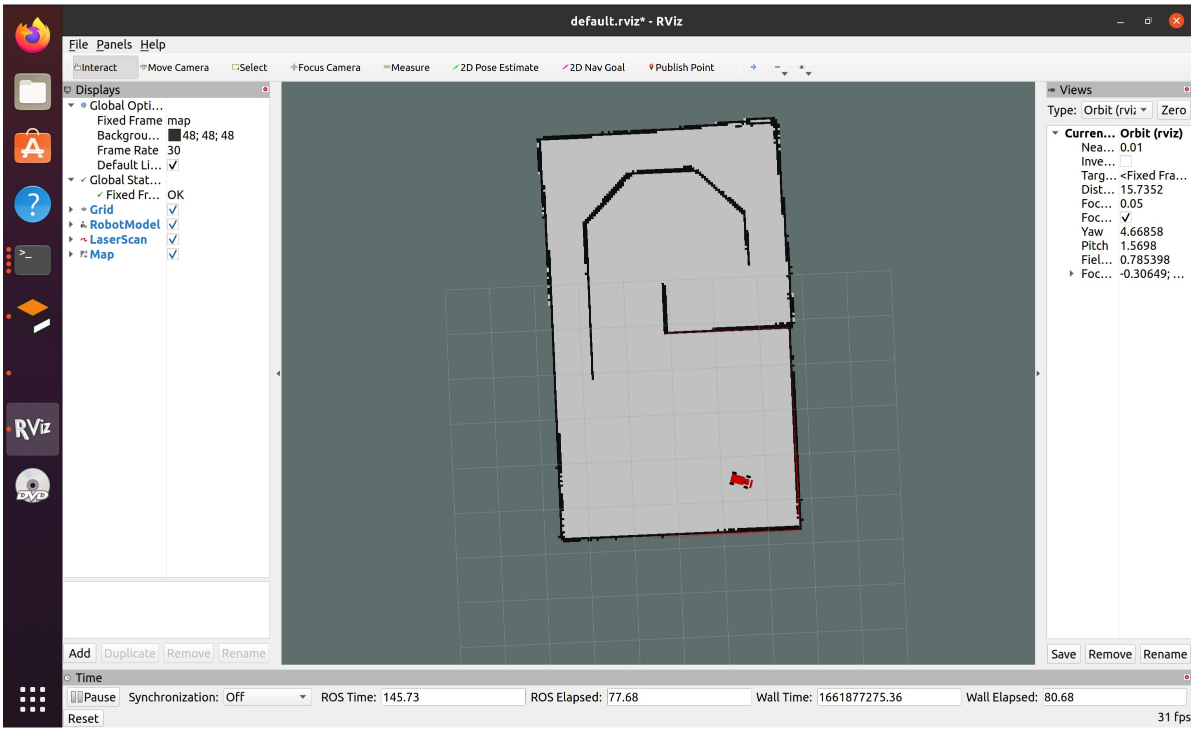
    ```
    roslaunch gazebo_pkg race.launch

    roslaunch racecar_control racecar_control.launch

    roslaunch gazebo_map slam_gmapping.launch   选用其它slam算法则运行其对应的launch文件，即slam_xxxxxxxx.launch
    ```

    - 打开**Rviz**

      点击左下角**Add**，于*By dispaly type*中添加**RobotModel**，于*By topic*中添加**Map**、**LaserScan**

    - 点击右上角*file—>save config as*，将Rviz配置文件命名为demo.rviz存放于cfg文件夹中

2. **完成建图**
    - **控制机器人运动，进行建图**，当你看到如下画面，**恭喜你！**完成了一张二维栅格地图的构建



2.5 保存地图

- 终端运行以下命令保存地图

  ```
  rosrun map_server map_saver -f mapname
  ```

  若所建地图不够好，可在保存地图时调整阈值参数。–occ为无法通行的阈值，–free为可通行的阈值，命令行：

  ```
  rosrun map_server map_saver --occ 70 --free 30 -f mapname
  ```

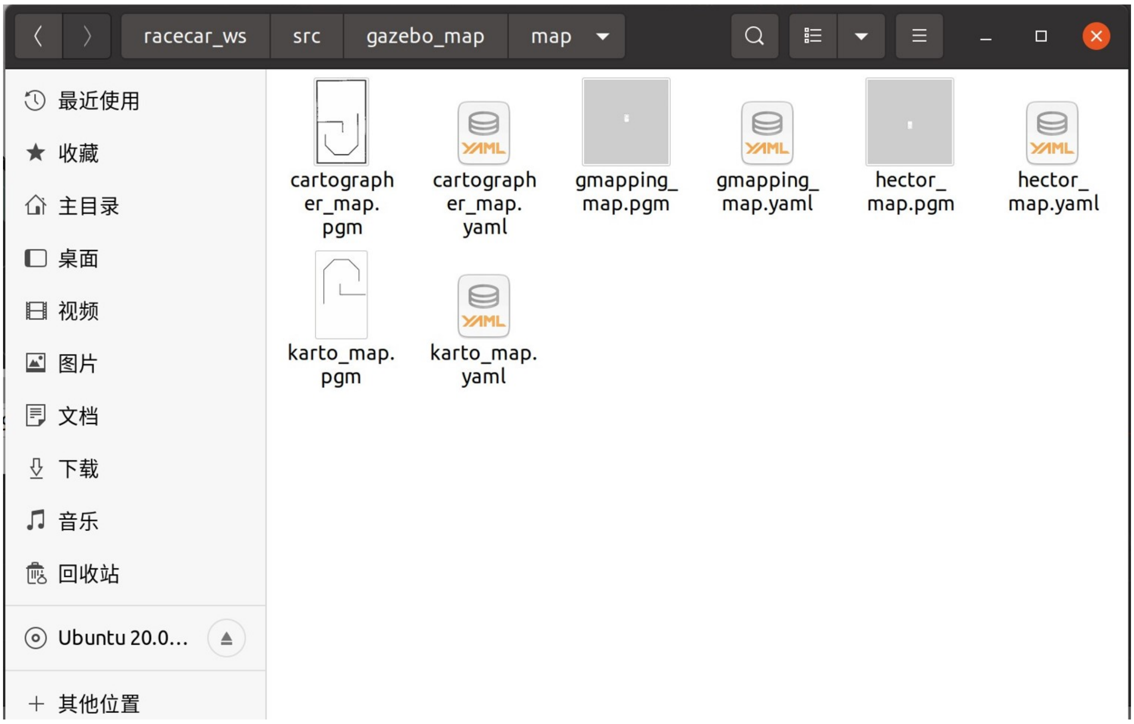
  若–occ过高，则可能出现墙体边缘出现灰色未探索地块；若–occ过低，则无墙体部分可能会被凭空建墙。

  若–free过高，则可能出现墙体被认为是自由区域；若–free过低，则自由区域可能出现灰色未探索地块。

  - 若无法保存地图则可能为没有安装map_server，终端中输入：

    ```
    sudo apt-get install ros-版本-map-server
    ```

- 地图默认保存于主目录下，将其移至**map文件夹**下完成建图



三、导航功能包创建

3.1 安装导航功能包

- **打开终端输入：**

```
sudo apt-get install ros-版本-navigation
```

3.2 在workspace/src下创建gazebo_nav功能包

- **打开终端依次输入**

```
cd workspace/src

catkin_create_pkg gazebo_nav

cd ..

catkin_make
```

3.3 于gazebo_nav功能包下创建cfg、launch、map文件夹

cfg文件夹存放的是参数配置文件

launch文件夹存放的是导航节点启动文件

map文件夹存放的是导航使用的地图图片和配置文件(yaml)

- **于cfg文件夹下创建amcl、move_base、rviz三个文件夹**

  amcl文件夹存放的是*AMCL*(adaptive Monte Carlo Localization)自适应蒙特卡洛**定位功能包**所需的参数配置文件

  move_base文件夹存放的是move_base**导航与路径规划功能包**所需的参数配置文件

  rviz文件夹存放的是rviz的配置文件

3.4 配置机器人定位启动文件

- 于cfg/amcl文件夹下创建amcl.launch文件
- 将以下代码复制至amcl.launch文件中

```
<launch>
    <arg name="scan_topic" default="scan"/>
    <arg name="initial_pose_x" default="0.18"/>
    <arg name="initial_pose_y" default="0.0"/>
    <arg name="initial_pose_a" default="3.1415926"/>

    <node pkg="amcl" type="amcl" name="amcl" clear_params="true">
        <param name="min_particles"             value="500"/>
        <param name="max_particles"             value="3000"/>
```

```
        <param name="kld_err"                   value="0.02"/>
        <param name="update_min_d"              value="0.20"/>
        <param name="update_min_a"              value="0.20"/>
        <param name="resample_interval"         value="1"/>
        <param name="transform_tolerance"       value="0.5"/>
        <param name="recovery_alpha_slow"       value="0.00"/>
        <param name="recovery_alpha_fast"       value="0.00"/>
        <param name="initial_pose_x"            value="$(arg 
initial_pose_x)"/>
        <param name="initial_pose_y"            value="$(arg 
initial_pose_y)"/>
        <param name="initial_pose_a"            value="$(arg 
initial_pose_a)"/>
        <param name="gui_publish_rate"          value="50.0"/>

        <remap from="scan"                      to="$(arg scan_topic)"/>
        <param name="laser_max_range"           value="3.5"/>
        <param name="laser_max_beams"           value="180"/>
        <param name="laser_z_hit"               value="0.5"/>
        <param name="laser_z_short"             value="0.05"/>
        <param name="laser_z_max"               value="0.05"/>
        <param name="laser_z_rand"              value="0.5"/>
        <param name="laser_sigma_hit"           value="0.2"/>
        <param name="laser_lambda_short"        value="0.1"/>
        <param name="laser_likelihood_max_dist" value="2.0"/>
        <param name="laser_model_type"          value="likelihood_field"/>

        <param name="odom_model_type"           value="diff"/>
        <param name="odom_alpha1"               value="0.1"/>
        <param name="odom_alpha2"               value="0.1"/>
        <param name="odom_alpha3"               value="0.1"/>
        <param name="odom_alpha4"               value="0.1"/>
        <param name="odom_frame_id"             value="odom"/>
        <param name="base_frame_id"             value="base_link"/>
    </node>
</launch>
```

3.5 配置导航参数文件

- 于cfg/move_base文件夹下分别创建move_base_params.yaml、costmap_common_params.yaml、global_costmap_params.yaml、global_planner_params.yam、local_costmap_params.yaml、dwa_local_planner_params.yaml、teb_local_planner_params.yaml文件:

1. **将以下代码复制至move_base_params.yaml文件**

```
shutdown_costmaps: false #当move_base在不活动状态时,是否关掉costmap

controller_frequency: 5.0 #向底盘控制移动话题cmd_vel发送命令的频率.
controller_patience: 3.0

planner_frequency: 0.5
```

```
planner_patience: 5.0

#机器人必须移动多远（以米计）才能被视为不摆动。
#如果出现摆动则说明全局规划失败，那么将在超时后执行恢复模块
oscillation_timeout: 10.0
oscillation_distance: 0.1

conservative_reset_dist: 0.1
```

2. **将以下代码复制至costmap_common_params.yaml文件**

```
#Description:
# 代价地图通用参数配置文件,就是全局代价地图和局部代价地图
# 共同都需要配置的参数,各参数意义如下:
# robot_radius: 机器人的半径
# "obstacle_range" 参数确定最大范围传感器读数，这将导致障碍物被放入代价地图中。
# 在这里，我们把它设置在3米，这意味着机器人只会更新其地图包含距离移动基座3米以内的障碍物的信息。
# “raytrace_range”参数确定了用于清除指定范围外的空间。
# 将其设置为3.0米，这意味着机器人将尝试清除3米外的空间，在代价地图中清除3米外的障碍物。

footprint: [[0.10, 0.10], [0.10, -0.10], [-0.10, -0.10], [-0.10, 0.10]]

obstacle_range: 2.5
raytrace_range: 3.0

static_layer:
  enabled: true


obstacle_layer:
  enabled: true
  track_unknown_space: true
  combination_method: 1

  obstacle_range: 2.5
  raytrace_range: 3.0

  observation_sources: scan
  scan: {
    data_type: LaserScan,
    topic: /scan,
    marking: true,
    clearing: true
  }
```

3. **将以下代码复制至global_costmap_params.yaml文件**

```
#Description:
#  全局代价地图参数配置文件,各参数的意义如下:
#  global_frame:在全局代价地图中的全局坐标系;
#  robot_base_frame:机器人的基坐标系;
#
global_costmap:
  global_frame: map
  robot_base_frame: base_link    # base_footprint
```

```
  transform_tolerance: 0.5

  update_frequency: 15.0
  publish_frequency: 10.0

  plugins:
    - {name: static_layer,    type: "costmap_2d::StaticLayer"}
    - {name: obstacle_layer,  type: "costmap_2d::ObstacleLayer"}
    - {name: inflation_layer, type: "costmap_2d::InflationLayer"}


  inflation_layer:
    enabled:              true
    cost_scaling_factor:  10.0  # exponential rate at which the obstacle
cost drops off (default: 10)
    inflation_radius:     0.4  # max. distance from an obstacle at which
costs are incurred for planning paths.
```

4. **将以下代码复制至global_planner_params.yaml文件**

```
#Description:
#   * allow_unknown:是否允许规划器规划穿过未知区域的路径,
#        只设计该参数为true还不行,还要在costmap_commons_params.yaml
#        中设置track_unknown_space参数也为true才行.
#   * default_tolerance:当设置的目的地被障碍物占据时,需要以该参数
#        为半径寻找到最近的点作为新目的地点.
#   * visualize_potential:是否显示从PointCloud2计算得到的势区域.
#   * use_dijkstra:设置为true,将使用dijkstra算法,否则使用A*算法.
#   * use_quadratic:设置为true,将使用二次函数近似函数,否则使用更加
#      简单的计算方式,这样节省硬件计算资源.
#   * use_grid_path:如果设置为true,则会规划一条沿着网格边界的路径,
#      偏向于直线穿越网格,否则将使用梯度下降算法,路径更为光滑点.
#   * old_navfn_behavior:若在某些情况下,想让global_planner完全复制navfn
#      的功能,那就设置为true,但是需要注意navfn是非常旧的ROS系统中使用的,
#      现在已经都用global_planner代替navfn了,所以不建议设置为true.
#   * lethal_cost:致命代价值,默认是设置为253,可以动态来配置该参数.
#   * neutral_cost:中等代价值,默认设置是50,可以动态配置该参数.
#   * cost_factor:代价地图与每个代价值相乘的因子.
#   * publish_potential:是否发布costmap的势函数.
#   * orientation_mode: 如何设置每个点的方向(None = 0,Forward = 1,
#       Interpolate = 2,ForwardThenInterpolate = 3,Backward = 4,
#       Leftward = 5,Rightward = 6)(可动态重新配置)
#   * orientation_window_size:根据orientation_mode指定的位置积分来得到
#      使用窗口的方向.默认值1,可以动态重新配置.
GlobalPlanner:
  allow_unknown: true
  default_tolerance: 0.05
  use_dijkstra: true
  use_quadratic: true
  use_grid_path: false
  outline_map: false
  old_navfn_behavior: false

  visualize_potential: false
  publish_potential: true

  lethal_cost: 253
```

```
  neutral_cost: 50
  cost_factor: 3.0

  orientation_mode: 0
  orientation_window_size: 1
```

5. **将以下代码复制至local_costmap_params.yaml文件**

```
#Description:
#  本地代价地图需要配置的参数，各参数意义如下:
#  global_frame:在本地代价地图中的全局坐标系;
#  robot_base_frame:机器人本体的基坐标系;

local_costmap:
  # global_frame: odom
  global_frame: map
  robot_base_frame:  base_link     # base_footprint
  transform_tolerance: 0.5

  # update_frequency: 10.0
  # publish_frequency: 10.0
  update_frequency: 15.0
  publish_frequency: 10.0
  rolling_window: true
  width: 15
  height: 15
  resolution: 0.05

  plugins:
    - {name: obstacle_layer,   type: "costmap_2d::ObstacleLayer"}
    - {name: inflation_layer, type: "costmap_2d::InflationLayer"}


  inflation_layer:
    enabled:              true
    cost_scaling_factor:  10.0  # exponential rate at which the obstacle
cost drops off (default: 10)
    inflation_radius:     0.2  # max. distance from an obstacle at which
costs are incurred for planning paths.
```

6. **将以下代码复制至dwa_local_planner_params.yaml文件**

```
#Description:
#  dwa_local_planner提供一个能够驱动底座的控制器,该控制器连接了路径规划器和机器人.
#  使用地图,规划器产生从起点到目标点的运动轨迹,在移动时,规划器在机器人周围产生一个函数,
#  用网格地图表示。控制器的工作就是利用这个函数来确定发送给机器人的速度dx, dy, dtheta
#
#       >> DWA算法的基本思想 <<
#  1.在机器人控制空间离散采样(dx, dy, dtheta)
#  2.对每一个采样的速度进行前向模拟,看看在当前状态下,使用该采样速度移动一小段时间后会发生什
么.
#  3.评价前向模拟得到的每个轨迹,是否接近障碍物,是否接近目标,是否接近全局路径以及速度等等.
舍弃非法路径
#  4.选择得分最高的路径,发送对应的速度给底座
#
```

```
#  DWA与Trajectory Rollout的区别主要是在机器人的控制空间采样差异.Trajectory Rollout采样点来源于整个
#  前向模拟阶段所有可用速度集合,而DWA采样点仅仅来源于一个模拟步骤中的可用速度集合.这意味着相比之下
#  DWA是一种更加有效算法,因为其使用了更小采样空间;然而对于低加速度的机器人来说可能Trajectory Rollout更好,
#  因为DWA不能对常加速度做前向模拟。
#
#  下面来依次介绍下每个参数的意义:
#   * acc_lim_x:x方向的加速度绝对值
#   * acc_lim_y:y方向的加速度绝对值,该值只有全向移动的机器人才需配置.
#   * acc_lim_th:旋转加速度的绝对值.
#
#   * max_trans_vel:平移速度最大值绝对值
#   * min_trans_vel:平移速度最小值的绝对值
#
#   * max_vel_x:x方向最大速度的绝对值
#   * min_vel_x:x方向最小值绝对值,如果为负值表示可以后退.
#   * max_vel_y:y方向最大速度的绝对值.
#   * min_vel_y:y方向最小速度的绝对值.
#
#   *trans_stopped_vel:停止的时候，最大的平移速度
#   *theta_stopped_vel:停止的时候，最大角速度
#
#   * max_rot_vel:最大旋转速度的绝对值.
#   * min_rot_vel:最小旋转速度的绝对值.
#   *
#   * yaw_goal_tolerance:到达目标点时偏行角允许的误差，单位弧度.
#   * xy_goal_tolerance:到达目标点时,在xy平面内与目标点的距离误差.
#   * latch_xy_goal_tolerance:设置为true,如果到达容错距离内,机器人就会原地
#        旋转,即使转动是会跑出容错距离外.
#
#   * sim_time:向前仿真轨迹的时间.
#   * sim_granularity:步长,轨迹上采样点之间的距离,轨迹上点的密集程度.
#   * vx_samples:x方向速度空间的采样点数.
#   * vy_samples:y方向速度空间采样点数.
#   * vth_samples:旋转方向的速度空间采样点数.
#   * controller_frequency:发送给底盘控制移动指令的频率.
#
#   * path_distance_bias:定义控制器与给定路径接近程度.
#   * goal_distance_bias:定义控制器与局部目标点的接近程度
#   * occdist_scale:定义控制器躲避障碍物的程度.
#   * stop_time_buffer:为防止碰撞,机器人必须提前停止的时间长度.
#   * scaling_speed:启动机器人底盘的速度.
#   * max_scaling_factor:最大缩放参数.
#
#   * publish_cost_grid:是否发布规划器在规划路径时的代价网格.如果设置为true,
#       那么就会在~/cost_cloud话题上发布sensor_msgs/PointCloud2类型消息.
#       每个点云代表代价网格,并且每个单独的评价函数都有一个字段及其每个单元
#       的总代价，并考虑评分参数.
#
#   * oscillation_reset_dist:机器人运动多远距离才会重置振荡标记.
#
#   * prune_plan:机器人前进是是否清楚身后1m外的轨迹.
latch_xy_goal_tolerance: true

DWAPlannerROS:
# Robot Configuration Parameters - stdr robot
```

```
  acc_lim_x: 0.3
  acc_lim_y: 0.3
  acc_lim_th: 0.6

#  max_trans_vel: 0.4#choose slightly less than the base's capability
#  min_trans_vel: 0.1 #this is the min trans velocity when there is
negligible rotational velocity

  max_vel_trans: 1.0 #choose slightly less than the base's capability
  min_vel_trans: -0.1 #this is the min trans velocity when there is
negligible rotational velocity

  trans_stopped_vel: 0.1
  theta_stopped_vel: 0.1

  max_vel_x: 1.5  #  0.8
  min_vel_x: -0.8
  max_vel_y: 1.8  #   0.2  diff drive robot,don't need set vel_y
  min_vel_y: -0.8

#  max_rot_vel: 0.5  #choose slightly less than the base's capability
#  min_rot_vel: 0.1  #this is the min angular velocity when there is
negligible translational velocity

  max_vel_theta: 1.9  #choose slightly less than the base's capability
  min_vel_theta: -0.9  #this is the min angular velocity when there is
negligible translational velocity


# Goal Tolerance Parameters
  yaw_goal_tolerance: 0.5  # 0.1 rad = 5.7 degree
  xy_goal_tolerance: 0.6
  latch_xy_goal_tolerance: true

# Forward Simulation Parameters
  sim_time: 1.0    # 1.7
  sim_granularity: 0.025
  vx_samples: 3    # default 3
  vy_samples: 3    # diff drive robot, there is only one sample
  vth_samples: 7  # 20
  controller_frequency: 5.0

# Trajectory Scoring Parameters
  path_distance_bias: 32.0  # 32.0  -weighting for how much it should stick
to the global path plan
  goal_distance_bias: 24.0  # 24.0  -wighting for how much it should attempt
to reach its goal
  occdist_scale: 0.08      # 0.05  -weighting for how much the controller
should avoid obstacles
  forward_point_distance: 0.125 # 0.325 -how far along to place an
additional scoring point
  stop_time_buffer: 0.6    # 0.2   -amount of time a robot must stop in
before colliding for a valid traj.
  scaling_speed: 0.20       # 0.25  -absolute velocity at which to start
scaling the robot's footprint
  max_scaling_factor: 0.2   # 0.2   -how much to scale the robot's footprint
when at speed.
  publish_cost_grid: false
```

```
# Oscillation Prevention Parameters
  oscillation_reset_dist: 0.05  # default 0.05

  hdiff_scale: 1.0 #全局和局部角度判断
  heading_points: 1

# Global Plan Parameters
  prune_plan: true

  publish_traj_pc : false
  publish_cost_grid_pc: false
  global_frame_id: map
```

7. **将以下代码复制至teb_local_planner_params.yaml文件**

```
TebLocalPlannerROS:

  odom_topic: odom
  map_frame: /map

  # Trajectoty 这部分主要是用于调整轨迹

  teb_autosize: True #优化期间允许改变轨迹的时域长度
  dt_ref: 0.3 #期望的轨迹时间分辨率
  dt_hysteresis: 0.03 #根据当前时间分辨率自动调整大小的滞后现象，通常约为。建议使用dt
ref的10%

  #覆盖全局规划器提供的局部子目标的方向;规划局部路径时会覆盖掉全局路径点的方位角,
  #对于车辆的2D规划,可以设置为False,可实现对全局路径的更好跟踪。
  global_plan_overwrite_orientation: True

#指定考虑优化的全局计划子集的最大长度,如果为0或负数：禁用；长度也受本地Costmap大小的限制
  max_global_plan_lookahead_dist: 0.8

  feasibility_check_no_poses: 1 #检测位姿可到达的时间间隔，default：4

  #如果为true，则在目标落后于起点的情况下，可以使用向后运动来初始化基础轨迹
  #(仅在机器人配备了后部传感器的情况下才建议这样做）
  allow_init_with_backwards_motion: False

  global_plan_viapoint_sep: -1

  #参数在TebLocalPlannerROS::pruneGlobalPlan()函数中被使用
  #该参数决定了从机器人当前位置的后面一定距离开始裁剪
  #就是把机器人走过的全局路线给裁剪掉，因为已经过去了没有比较再参与计算后面的局部规划
  global_plan_prune_distance: 1

  exact_arc_length: False
  publish_feedback: False

  # Robot
  max_vel_x: 1.2
  max_vel_x_backwards: 0.8
  max_vel_theta: 1
  acc_lim_x: 2.5
  acc_lim_theta: 3.5
```

```
  #仅适用于全向轮
  # max_vel_y (double, default: 0.0)
  # acc_lim_y (double, default: 0.5)

  # ********************** Carlike robot parameters ********************
  min_turning_radius: 0.36     # 最小转弯半径 注意车辆运动学中心是后轮中点
  wheelbase: 0.36                # 即前后轮距离

#设置为true时，ROS话题（rostopic） cmd_vel/angular/z 内的数据是舵机角度，
  cmd_angle_instead_rotvel: True
  # **********************************************************************

  # footprint_model: # types: "point", "circular", "two_circles", "line",
"polygon" 多边形勿重复第一个顶点，会自动闭合
  #   type: "line"
  #   # radius: 0.2 # for type "circular"
  #   line_start: [-0.13, 0.0] # for type "line"
  #   line_end: [0.13, 0.0] # for type "line"
    # front_offset: 0.2 # for type "two_circles"
    # front_radius: 0.2 # for type "two_circles"
    # rear_offset: 0.2 # for type "two_circles"
    # rear_radius: 0.2 # for type "two_circles"
    # vertices: [ [0.25, -0.05], [0.18, -0.05], [0.18, -0.18], [-0.19,
-0.18], [-0.25, 0], [-0.19, 0.18], [0.18, 0.18], [0.18, 0.05], [0.25, 0.05]
] # for type "polygon"

  # GoalTolerance
  footprint_model:
    type: "polygon"
    vertices: [[0.15, 0.15], [0.15, -0.15], [-0.15, -0.15], [-0.15, 0.15]]


  xy_goal_tolerance: 0.3
  yaw_goal_tolerance: 1.0
  #自由目标速度。设为False时，车辆到达终点时的目标速度为0。
  #TEB是时间最优规划器。缺少目标速度约束将导致车辆“全速冲线”
  free_goal_vel: True

  # complete_global_plan: True
  # Obstacles

  min_obstacle_dist: 0.05 # 与障碍的最小期望距离,
  include_costmap_obstacles: True #应否考虑到局部costmap的障碍设置为True后才能规避
实时探测到的、建图时不存在的障碍物。
  costmap_obstacles_behind_robot_dist: 3.0 #考虑后面n米内的障碍物2.0
  obstacle_poses_affected: 30 #为了保持距离，每个障碍物位置都与轨道上最近的位置相连。
  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
  weight_max_vel_x: 2
```

```
  weight_max_vel_theta: 1
  weight_acc_lim_x: 1
  weight_acc_lim_theta: 2 #1
  weight_kinematics_nh: 1000
  weight_kinematics_forward_drive: 0.1 #1
  weight_kinematics_turning_radius: 1 #1
  weight_optimaltime: 1
  weight_obstacle: 10 #50
  weight_dynamic_obstacle: 10 # not in use yet
  alternative_time_cost: False # not in use yet
  selection_alternative_time_cost: False
  # Homotopy Class Planner

  enable_homotopy_class_planning: False
  enable_multithreading: False
  simple_exploration: False
  max_number_classes: 4
  roadmap_graph_no_samples: 15
  roadmap_graph_area_width: 5
  h_signature_prescaler: 0.5
  h_signature_threshold: 0.1
  obstacle_keypoint_offset: 0.1
  obstacle_heading_threshold: 0.45
  visualize_hc_graph: 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
```

3.6 配置导航启动文件

- 于launch文件夹下创建racecar_nav.launch文件
- **将以下代码复制至racecar_nav.launch文件**

```
<launch>

                <!--  *************** Global Parameters ***************  -->
  <param name="/use_sim_time" value="true"/>
  <!-- <arg name="load_state_filename"
default="/home/hzh/HangTian_test_ws/src/gazebo_map/map/carto_map1.pbstream"/
> -->

                <!--  ****** Maps *****  -->
    <node name="map_server" pkg="map_server" type="map_server" args="$(find
gazebo_nav)/map/gmapping_map.yaml" output="screen">
   <param name="frame_id" value="map" />
  </node>
```

```xml
  <!-- <node name="cartographer_node" pkg="cartographer_ros"
           type="cartographer_node" args="
                        -configuration_directory $(find gazebo_nav)/launch
                        -configuration_basename
my_backpack_2d_localization.lua
                        -load_state_filename $(arg load_state_filename)"
           output="screen">

        <remap from="echoes" to="scan" />
    </node> -->

        <!--  ************** Navigation ***************  -->
    <node pkg="move_base" type="move_base" respawn="false" name="move_base"
output="screen">


  <rosparam file="$(find
gazebo_nav)/cfg/move_base/costmap_common_params.yaml" command="load"
ns="global_costmap" />
    <rosparam file="$(find
gazebo_nav)/cfg/move_base/costmap_common_params.yaml" command="load"
ns="local_costmap" />
    <rosparam file="$(find
gazebo_nav)/cfg/move_base/global_planner_params.yaml" command="load" />
    <rosparam file="$(find
gazebo_nav)/cfg/move_base/teb_local_planner_params.yaml" command="load" />
    <rosparam file="$(find
gazebo_nav)/cfg/move_base/local_costmap_params.yaml" command="load" />
    <rosparam file="$(find
gazebo_nav)/cfg/move_base/global_costmap_params.yaml" command="load" />
    <rosparam file="$(find gazebo_nav)/cfg/move_base/move_base_params.yaml"
command="load" />

    <param name="planner_frequency" value="10" />
    <param name="planner_patience" value="15" />
    <!--param name="use_dijkstra" value="true" /-->
    <param name="base_local_planner"
value="teb_local_planner/TebLocalPlannerROS" />
    <param name="controller_frequency" value="20.0" />
    <param name="controller_patience" value="20.0" />
    <param name="clearing_rotation_allowed" value="false" />
    <param name="base_global_planner" value="global_planner/GlobalPlanner"/>

  </node>

  <!--<node name="cartographer_occupancy_grid_node" pkg="cartographer_ros"
            type="cartographer_occupancy_grid_node" args="-resolution
0.05" />  -->

      <!--  *************** Visualisation ***************  -->

  <!-- <node name="rviz" pkg="rviz" type="rviz" required="true"
          args="-d $(find gazebo_nav)/launch/config/rviz/demo1.rviz" /> --
>

</launch>
```

3.7 更改地图路径

- 将导航要使用的.pgm文件以及对应的.yaml文件复制至gazebo_nav功能包的map文件夹下
- 更改racecar_nav.launch文件中地图文件的路径改为自己的路径：

  ```
  <node name="map_server" pkg="map_server" type="map_server" args="$(find
  gazebo_nav)/map/gmapping_map.yaml" output="screen">
     <param name="frame_id" value="map" />
  </node>
  ```

3.8 开始导航

1. **保存rviz配置**
   - 于终端中依次打开以下节点启动文件

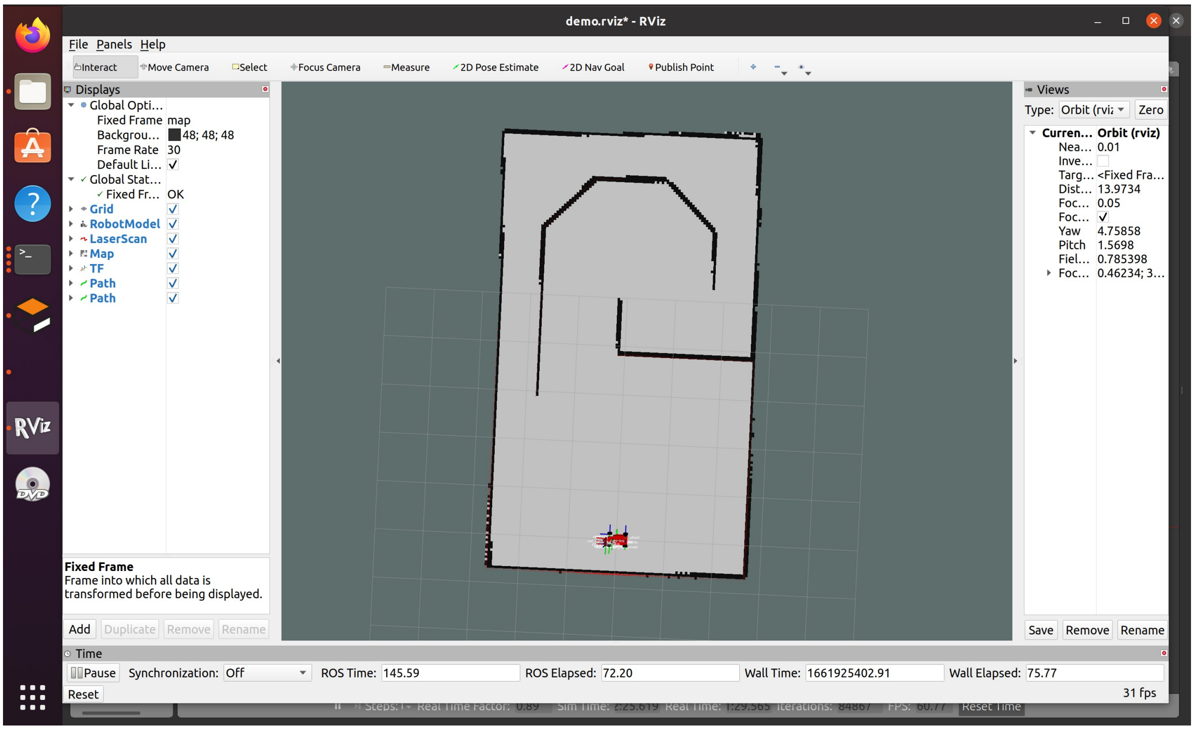
     ```
     roslaunch gazebo_pkg race.launch

     roslaunch racecar_control racecar_control.launch

     roslaunch gazebo_nav racecar_nav.launch

     roslaunch gazebo_nav amcl.launch
     ```

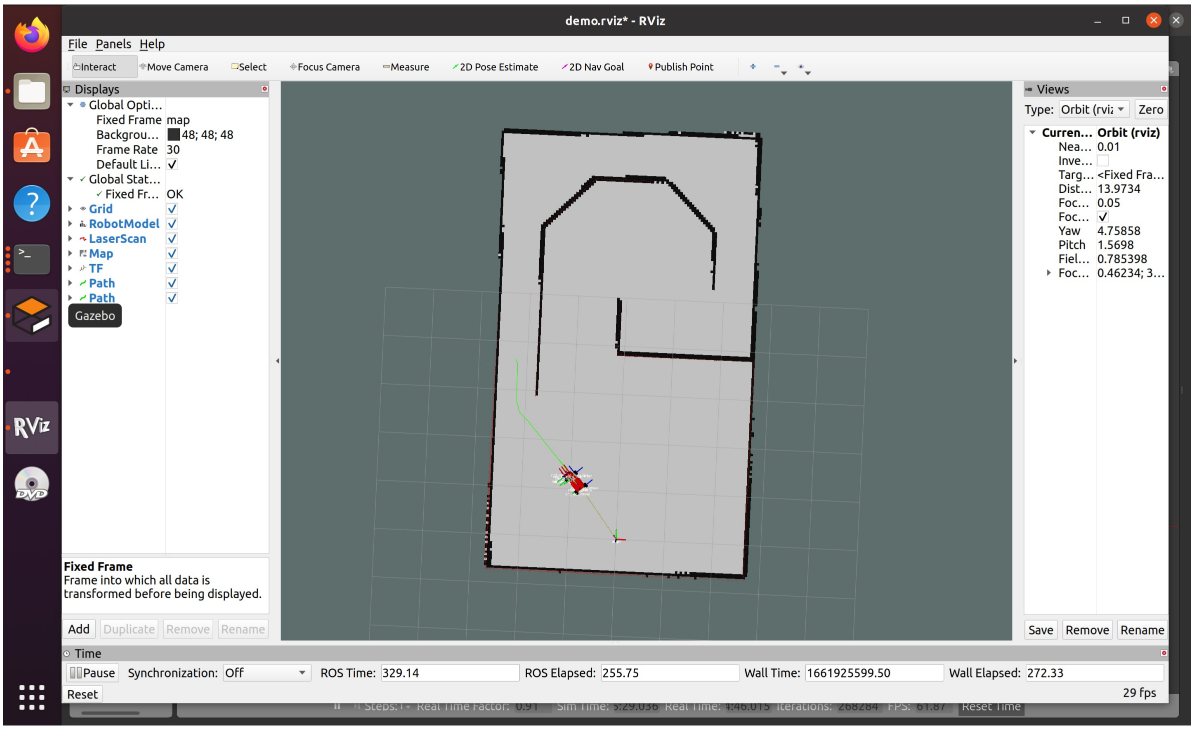
   - 打开**Rviz**

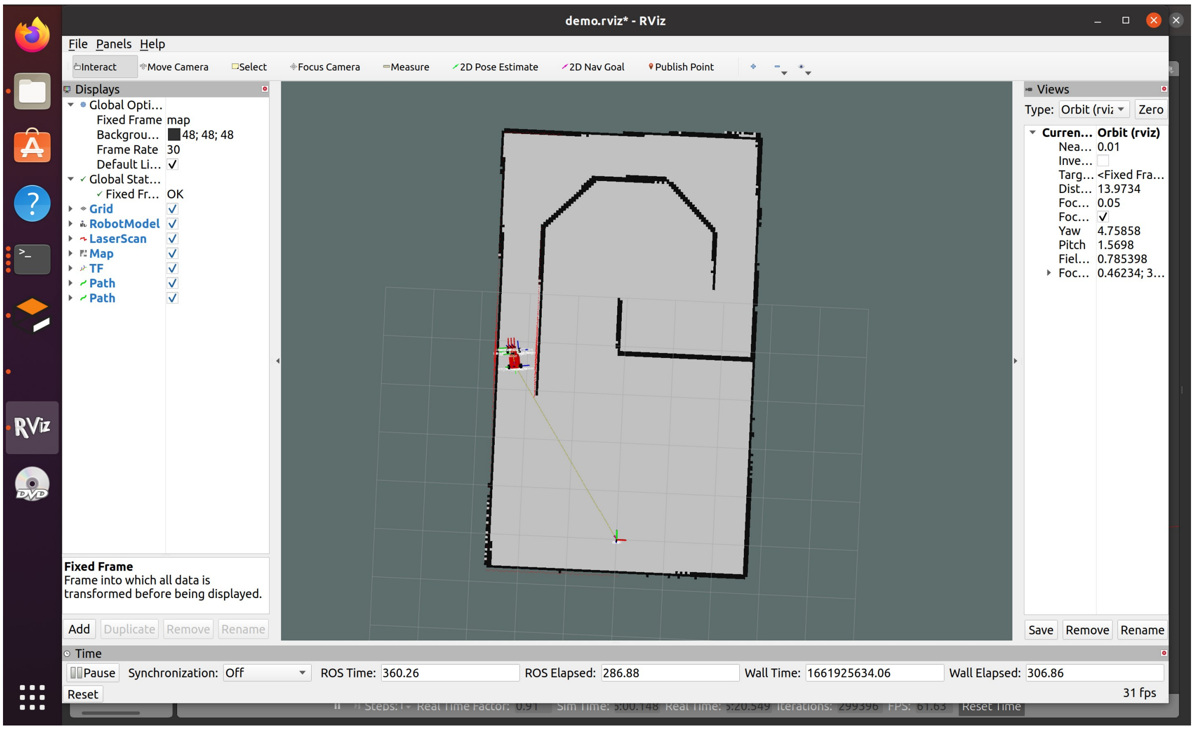
     点击左下角**Add**，于*By dispaly type*中添加**RobotModel**、**TF**，于*By topic*中添加**Map**、**LaserScan**、**move_base/GlobalPlanner/plan/Path**、**move_base/TebLocalPlannerROS/local_plan/Path**
   - 点击右上角*file—>save config as*，将Rviz配置文件命名为demo.rviz存放于cfg/rviz文件夹中

2. **完成导航**

   相信你此时已经能够看到如下画面了，**恭喜你！**终于走到了最后一步：
   - 选择上方菜单栏的**2D Nav Goal**，在地图上打下一个目标点，机器人就会导航至目标点啦！


demo.rviz* - RViz
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Opti…
Fixed Frame map
Backgrou… 48; 48; 48
Frame Rate 30
Default Li…
Global Stat…
Fixed Fr… OK
Grid
RobotModel
LaserScan
Map
TF
Path
Path
Fixed Frame
Frame into which all data is transformed before being displayed.
Add Duplicate Remove Rename
Views
Type: Orbit (rviz
Zero
Curren… Orbit (rviz)
Nea… 0.01
Inve…
Targ… <Fixed Fra…
Dist… 13.9734
Foc… 0.05
Foc…
Yaw 4.75858
Pitch 1.5698
Fiel… 0.785398
Foc… 0.46234; 3…
Save Remove Rename
Time
Pause
Synchronization: Off
ROS Time: 145.59
ROS Elapsed: 72.20
Wall Time: 1661925402.91
Wall Elapsed: 75.77
Reset
31 fps


demo.rviz* - RViz
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Opti…
Fixed Frame map
Backgrou… 48; 48; 48
Frame Rate 30
Default Li…
Global Stat…
Fixed Fr… OK
Grid
RobotModel
LaserScan
Map
TF
Path
Path
Gazebo
Fixed Frame
Frame into which all data is transformed before being displayed.
Add Duplicate Remove Rename
Views
Type: Orbit (rviz
Zero
Curren… Orbit (rviz)
Nea… 0.01
Inve…
Targ… <Fixed Fra…
Dist… 13.9734
Foc… 0.05
Foc…
Yaw 4.75858
Pitch 1.5698
Fiel… 0.785398
Foc… 0.46234; 3…
Save Remove Rename
Time
Pause
Synchronization: Off
ROS Time: 329.14
ROS Elapsed: 255.75
Wall Time: 1661925599.50
Wall Elapsed: 272.33
Reset
29 fps


demo.rviz* - RViz
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Global Opti...
Fixed Frame map
Backgrou... 48; 48; 48
Frame Rate 30
Default Li...
Global Stat...
Fixed Fr... OK
Grid
RobotModel
LaserScan
Map
TF
Path
Path
Fixed Frame
Frame into which all data is transformed before being displayed.
Add
Duplicate
Remove
Rename
Views
Type: Orbit (rviz
Zero
Curren... Orbit (rviz)
Nea... 0.01
Inve...
Targ... <Fixed Fra...
Dist... 13.9734
Foc... 0.05
Foc...
Yaw 4.75858
Pitch 1.5698
Fiel... 0.785398
Foc... 0.46234; 3...
Save
Remove
Rename
Time
Pause
Synchronization: Off
ROS Time: 360.26
ROS Elapsed: 286.88
Wall Time: 1661925634.06
Wall Elapsed: 306.86
Reset
31 fps