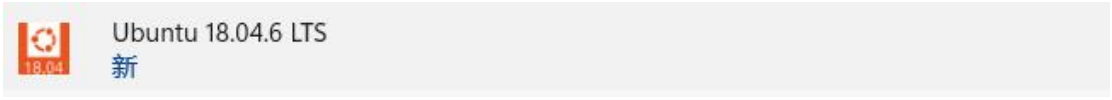
安装 Ubuntu: 项目在 Ubuntu 16.04（ROS Kinetic）和 18.04（ROS Melodic）上进行了测试。这里我选用了 Ubuntu 18.04 操作。



WSL(Windows Subsystem Linux)的安装

1. 在系统 BIOS 中打开 CPU 虚拟化技术（Intel Virtual Technology 或 SVM）

2. 在系统搜索栏中搜索“启用或关闭 Windows 功能”， 并打开以下选项

3. 在官网下载最新的 WSL2 Linux 内核升级。用管理员身份打开终端，输入 ：

```
wsl .exe --update
```

4. 在微软商店里搜索 Ubuntu 22.04.X LTS，安装即可

5.进行基本的 Ubuntu 配置，看到 `[设置用户名]@设备名:~$` 即为成功

6.换国内镜像源，更新 apt 库

备份原本的 source.list文件

```
sudo cp /etc/apt/sources.list /etc/apt/sources.list.bkup
```

在 vim 的输入模式下（运行 `sudo vim /etc/apt/sources.list`)并将下面新的镜像源网站粘贴进 source.list文件中，并通过 `:wq` 保存退出。

```
# 默认注释了源码镜像以提高 apt update 速度，如有需要可自行取消注释 deb https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ jammy m
# deb-src https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ j deb https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ jammy-u
# deb-src https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ j deb https://mirrors.tuna.tsinghua.edu.cn/ubuntu/ jammy-b
```

分别运行 `sudo apt update` 和 `sudo apt upgrade`

安装依赖：需要安装一些必要的工具。通过运行以下命令来安装 libarmadillo 库和 ROS 的 nlopt 包：

```
liu@LAPTOP-G5I4C2UR:~$   sudo apt-get install libarmadillo-dev ros-melodic-nlopt
[sudo] password for liu:
Reading package lists... Done
Building dependency tree
Reading state information... Done
libarmadillo-dev is already the newest version (1:8.400.0+dfsg-2).
ros-melodic-nlopt is already the newest version (2.1.24-2bionic.20230621.131609).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

克隆 FUEL 项目：进入到你的 ROS 工作空间的 src 目录，然后克隆 FUEL 项目的代码库（这里使用的是 SSH 方式）：

cd ${YOUR_WORKSPACE_PATH}/src

git clone git@github.com:HKUST-Aerial-Robotics/FUEL.git

cd ..

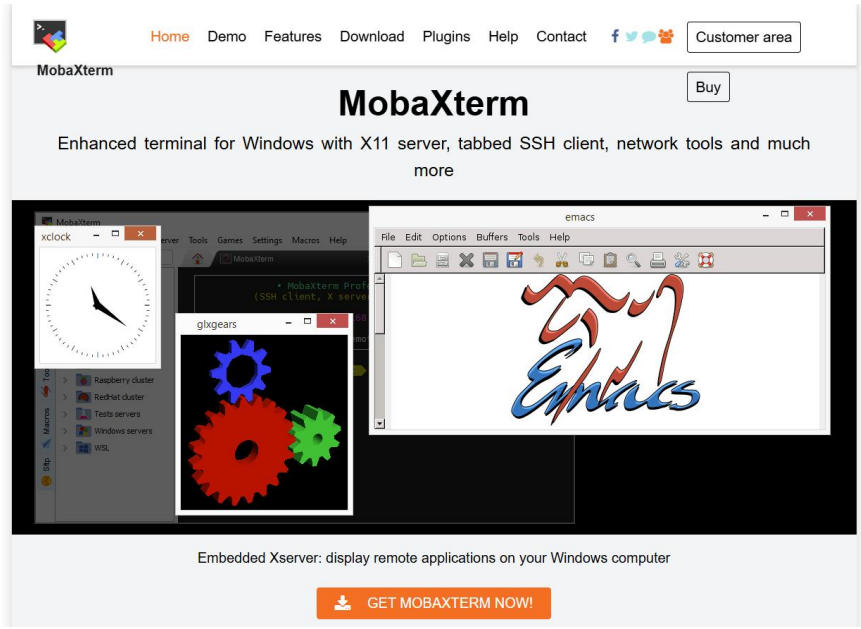
编译项目：使用 catkin_make 命令来编译项目：

```
liu@LAPTOP-G5I4C2UR:~/FUEL$ catkin_make
Base path: /home/liu/FUEL
Source space: /home/liu/FUEL/src
Build space: /home/liu/FUEL/build
Devel space: /home/liu/FUEL/devel
Install space: /home/liu/FUEL/install
Creating symlink "/home/liu/FUEL/src/CMakeLists.txt" pointing to "/opt/ros/melodic/share/catkin/cmake/toplevel.cmake"
####
#### Running command: "cmake /home/liu/FUEL/src -DCATKIN_DEVEL_PREFIX=/home/liu/FUEL/devel -DCMAKE_INSTALL_PREFIX=/home/liu/FUEL/install -G Unix Makefiles"
in "/home/liu/FUEL/build"
####
-- The C compiler identification is GNU 7.5.0
-- The CXX compiler identification is GNU 7.5.0
-- Check for working C compiler: /usr/bin/cc
-- Check for working C compiler: /usr/bin/cc -- works
-- Detecting C compiler ABI info
-- Detecting C compiler ABI info - done
-- Detecting C compile features
-- Detecting C compile features - done
-- Check for working CXX compiler: /usr/bin/c++
-- Check for working CXX compiler: /usr/bin/c++ -- works
-- Detecting CXX compiler ABI info
-- Detecting CXX compiler ABI info - done
-- Detecting CXX compile features
```

启动可视化工具：编译完成后，可以通过运行以下命令来启动 Rviz，用于可视化探索过程：

Error:Could not connect to any X display.

```
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-liu'
qt.qpa.screen: QXcbConnection: Could not connect to display
Could not connect to any X display.
[rvizvisualisation-2] process has died [pid 4417, exit code 1, cmd /opt/ros/melodic/lib/rviz/rviz -d /home/liu/FUEL/src/FUEL-main/fuel_planner/plan_manage/config/traj.rviz __name:=rvizvisualisation __log:=/home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/rvizvisualisation-2.log].
log file: /home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/rvizvisualisation-2*.log
```



source devel/setup.bash && roslaunch exploration_manager rviz.launch

```
liu@LAPTOP-G5I4C2UR:~$ cd FUEL/
liu@LAPTOP-G5I4C2UR:~/FUEL$ ls
build  devel  src
liu@LAPTOP-G5I4C2UR:~/FUEL$   source devel/setup.bash && roslaunch exploration_m
anager rviz.launch
... logging to /home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/roslaunch
-LAPTOP-G5I4C2UR-5326.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://LAPTOP-G5I4C2UR:59412/
```

Error:XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-liu'

```
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-liu'
[tf_53-2] process has finished cleanly
log file: /home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/tf_53-2*.log
[rvizvisualisation-1] process has died [pid 5347, exit code -11, cmd /opt/ros/me
lodic/lib/rviz/rviz -d /home/liu/FUEL/src/FUEL-main/fuel_planner/plan_manage/con
fig/traj.rviz __name:=rvizvisualisation __log:=/home/liu/.ros/log/2e6f03d6-2293-
11ef-a4f1-8c8caa1184cb/rvizvisualisation-1.log].
log file: /home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/rvizvisualisat
ion-1*.log
all processes on machine have died, roslaunch will exit
shutting down processing monitor...
... shutting down processing monitor complete
done
```

补充说明：

解决XDG_RUNTIME_DIR未设置的问题

当您遇到 XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root' 这个警告时，通常意味着您的系统缺少必要的环境变量来指定 XDG_RUNTIME_DIR 的位置。这个环境变量用于存放临时文件和运行时数据，对于许多图形界面应用程序来说是非常重要的。

解决方法：

方法一：设置环境变量：终端输入export XDG_RUNTIME_DIR=/usr/lib/

方法二：在/etc/profile末尾增加两句

```
1 export XDG_RUNTIME_DIR=/usr/lib/
2 export RUNLEVEL=3
```

复制

然后刷新全局变量

```
1 source /etc/profile
```

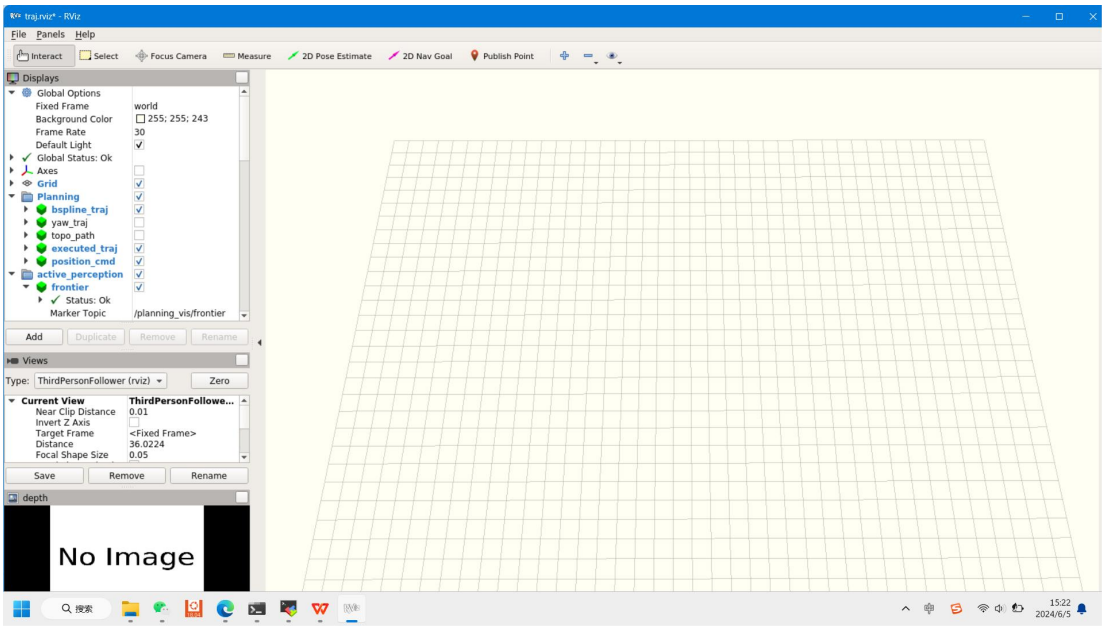
方法三：如果你的程序没有中断或严重BUG，那么该警告记录：

QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'好像并不影响页面显示和程序的正常运行。

Error:wrong ownership on runtime directory /usr/lib/,0 instead of 1000

```
liu@LAPTOP-G5I4C2UR:~/FUEL$ sudo su
[sudo] password for liu:
root@LAPTOP-G5I4C2UR:/home/liu/FUEL#   source devel/setup.bash && roslaunch exploration_manager rviz.launch
... logging to /root/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/roslaunch-LAPTOP-G5I4C2UR-8775.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://LAPTOP-G5I4C2UR:64586/

SUMMARY
========

PARAMETERS
 * /rosdistro: melodic
 * /rosversion: 1.14.13
```

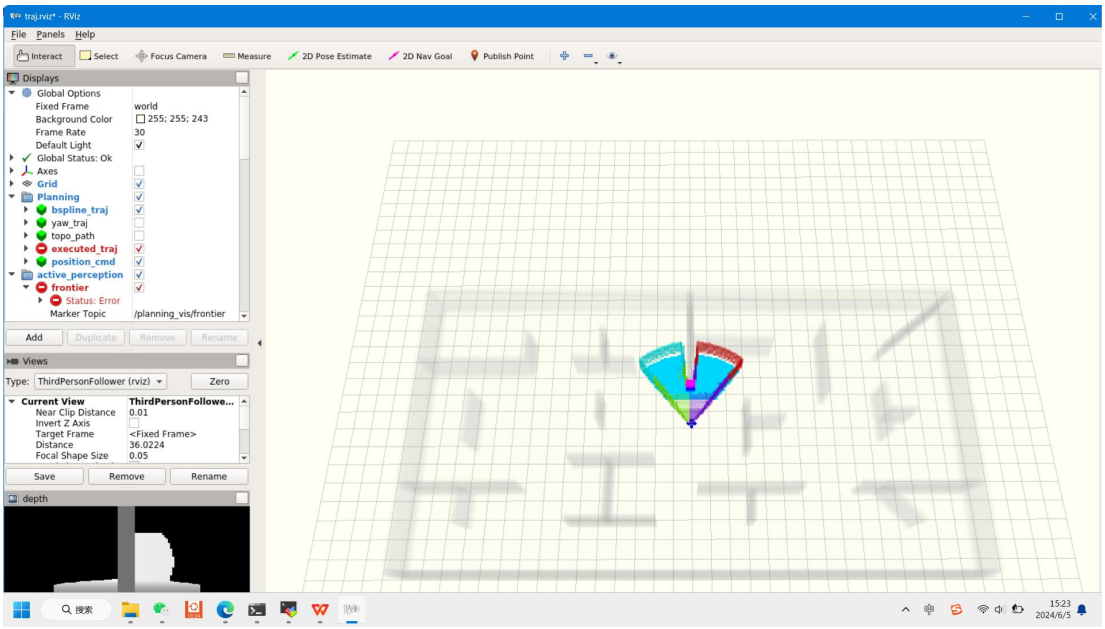
换到 root 用户下打开,成功

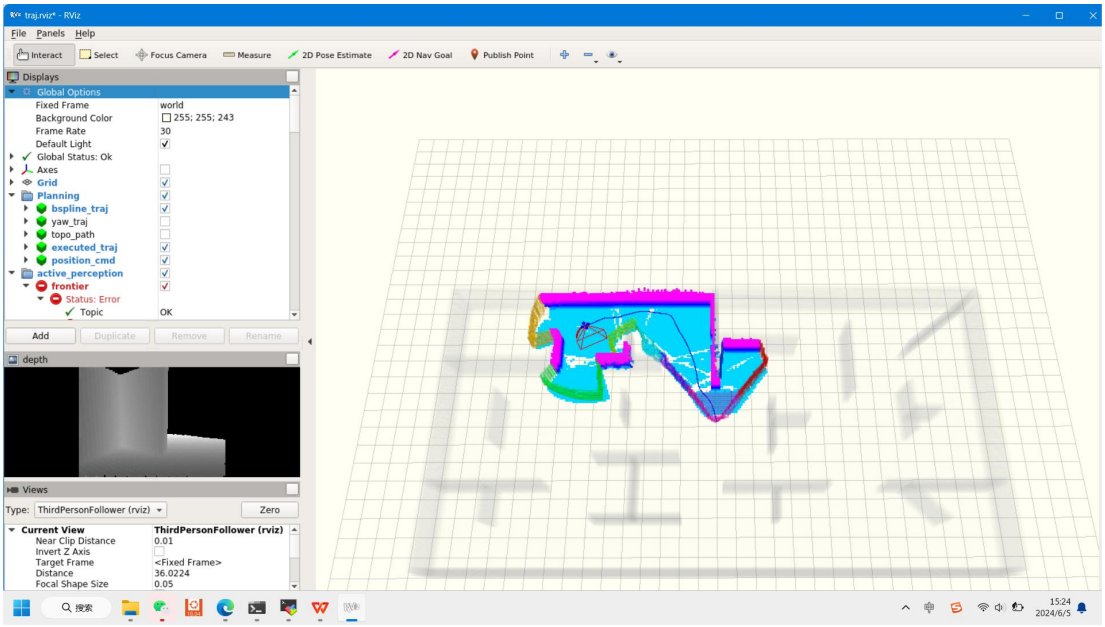


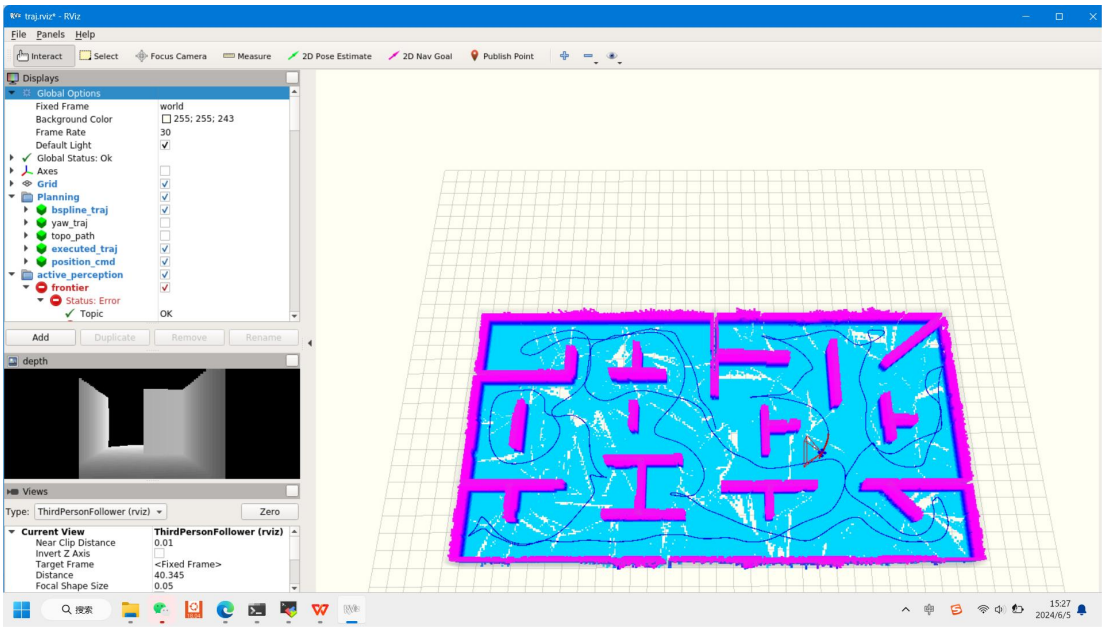
运行模拟: 在新的终端窗口中，运行模拟，触发四旋翼无人机开始探索：

```
liu@LAPTOP-G5I4C2UR:~$ pwd
/home/liu
liu@LAPTOP-G5I4C2UR:~$ cd FUEL
liu@LAPTOP-G5I4C2UR:~/FUEL$   source devel/setup.bash && roslaunch exploration_manager exploration.launch
... logging to /home/liu/.ros/log/2e6f03d6-2293-11ef-a4f1-8c8caa1184cb/roslaunch-LAPTOP-G5I4C2UR-9292.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://LAPTOP-G5I4C2UR:64961/

SUMMARY
========

PARAMETERS
 * /exploration_node/astar/allocate_num: 1000000
 * /exploration_node/astar/lambda_heu: 10000.0
 * /exploration_node/astar/max_search_time: 0.001
 * /exploration_node/astar/resolution_astar: 0.2
 * /exploration_node/bspline/limit_acc: 2.0
 * /exploration_node/bspline/limit_ratio: 1.1
 * /exploration_node/bspline/limit_vel: 2.0
 * /exploration_node/exploration/am: 2.0
 * /exploration_node/exploration/max_decay: 0.8
 * /exploration_node/exploration/refine_local: True
 * /exploration_node/exploration/refined_num: 7
 * /exploration_node/exploration/refined_radius: 5.0
 * /exploration_node/exploration/relax_time: 1.0
 * /exploration_node/exploration/top_view_num: 15
 * /exploration_node/exploration/tsp_dir: /home/liu/FUEL/sr...
```

source devel/setup.bash && roslaunch exploration_manager exploration.launch


traj.rviz* - RViz
File Panels Help
Interact Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Global Options
Fixed Frame world
Background Color 255; 255; 243
Frame Rate 30
Default Light
Global Status: Ok
Axes
Grid
Planning
bspline_traj
yaw_traj
topo_path
executed_traj
position_cmd
active_perception
frontier
Status: Error
Marker Topic /planning_vis/frontier
Add Duplicate Remove Rename
Views
Type: ThirdPersonFollower (rviz) Zero
Current View ThirdPersonFollowe...
Near Clip Distance 0.01
Invert Z Axis
Target Frame <Fixed Frame>
Distance 36.0224
Focal Shape Size 0.05
Save Remove Rename
depth
15:23
2024/6/5


traj.rviz* - RViz
File Panels Help
Interact Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Global Options
Fixed Frame world
Background Color 255; 255; 243
Frame Rate 30
Default Light
Global Status: Ok
Axes
Grid
Planning
bspline_traj
yaw_traj
topo_path
executed_traj
position_cmd
active_perception
frontier
Status: Error
Topic OK
Add Duplicate Remove Rename
depth
Views
Type: ThirdPersonFollower (rviz) Zero
Current View ThirdPersonFollower (rviz)
Near Clip Distance 0.01
Invert Z Axis
Target Frame <Fixed Frame>
Distance 36.0224
Focal Shape Size 0.05
15:24
2024/6/5


traj.rviz* - RViz
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Global Options
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Global Status: Ok
Axes
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bspline_traj
yaw_traj
topo_path
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Distance 40.345
Focal Shape Size 0.05
搜索
15:27
2024/6/5