ME5413 Final Project

Group 14

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Introduction

1: Mapping

2: Planning

3: Perception

Task 1: Mapping

Four different method

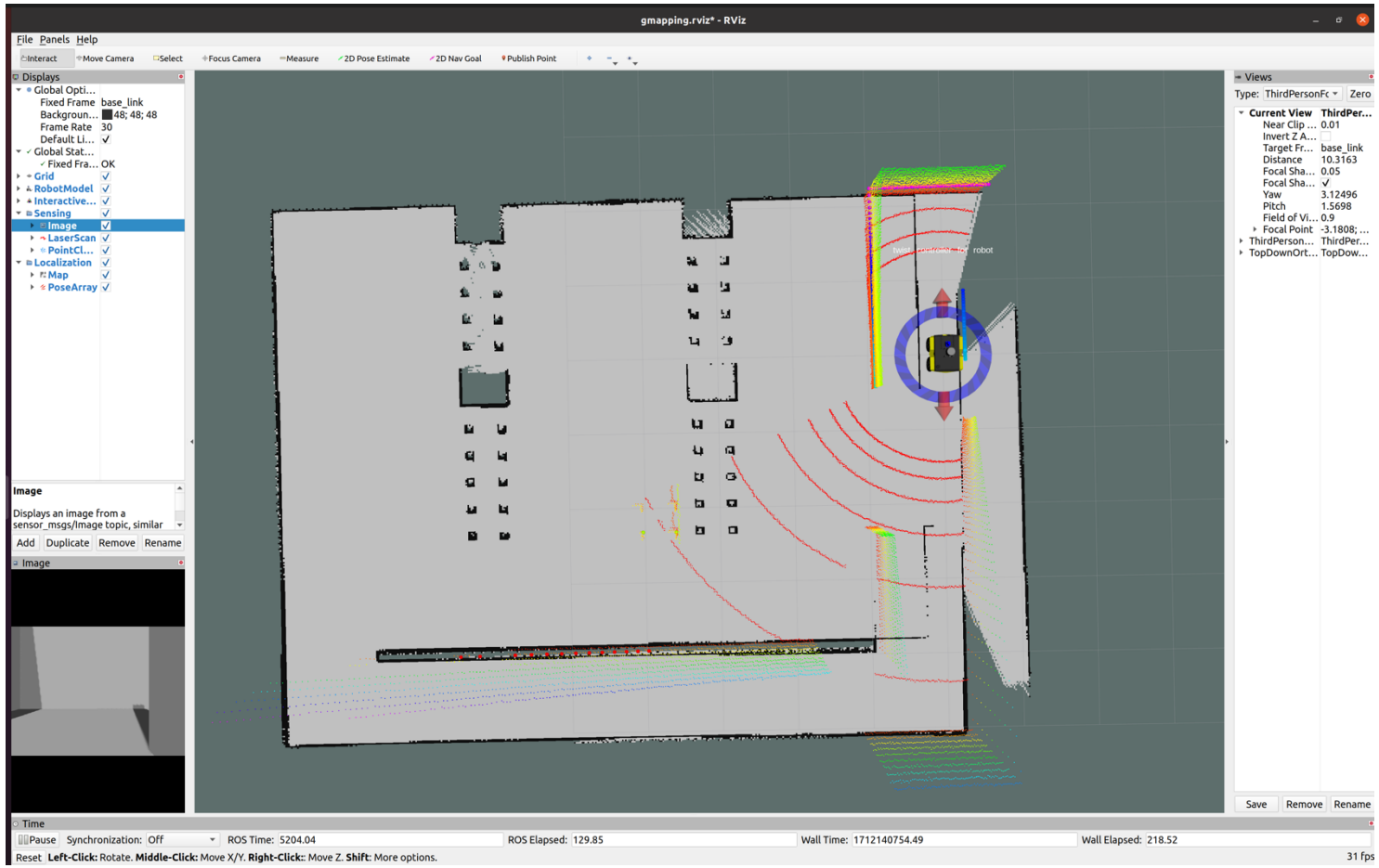
1: Gmapping
2: Cartographer 2D
3: Cartographer 3D
4: Fast-lio

Gmapping

Problem:

Robot could not locate itself accurately using default parameters, cause wall overlap.

Not enough parameters to optimize.



Cartographer 2D

Problem:

Default parameters will cause wall overlap.

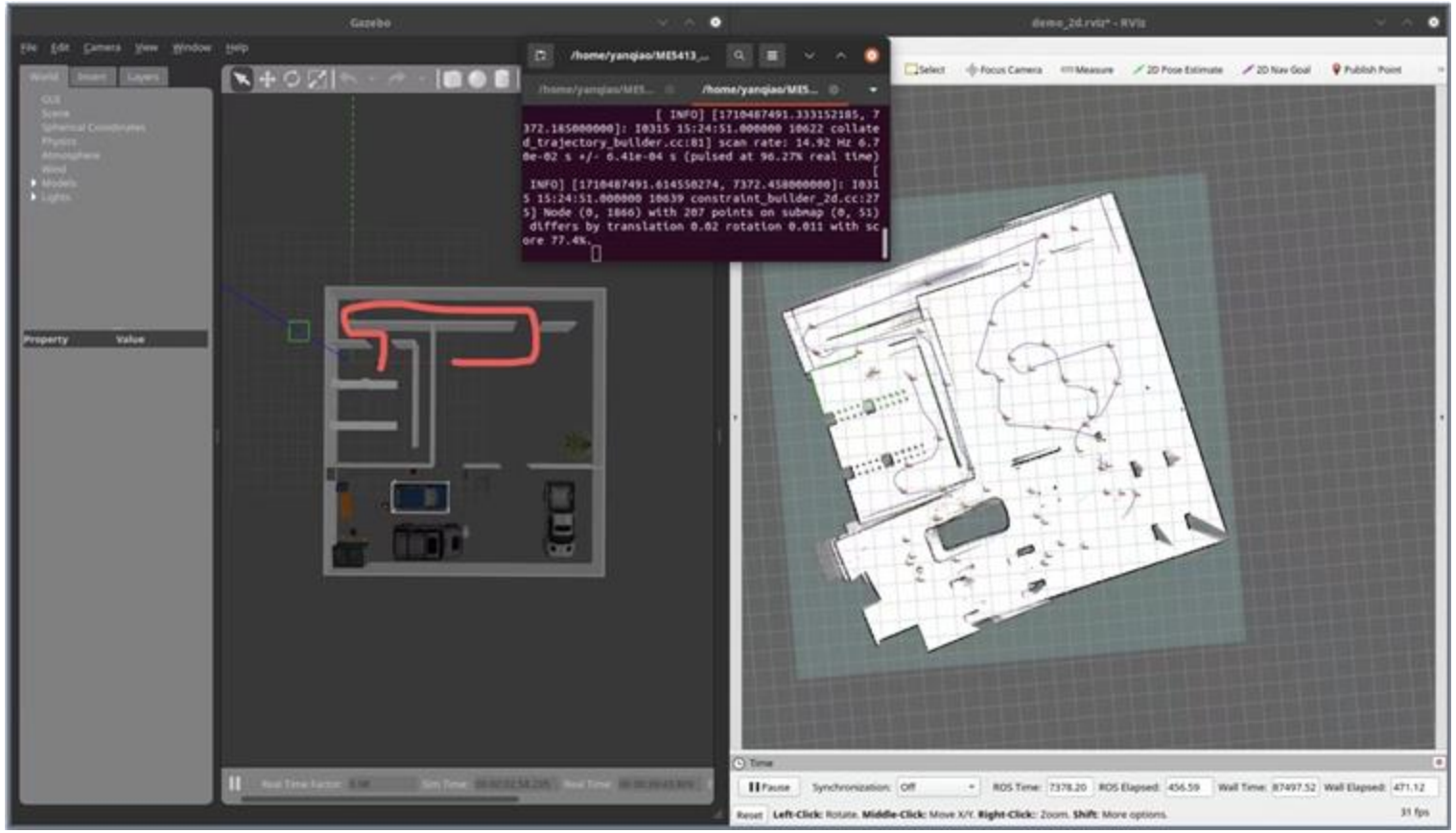
Solution:

Adjust Parameters:

submaps.num_range_data

min_range

max_range



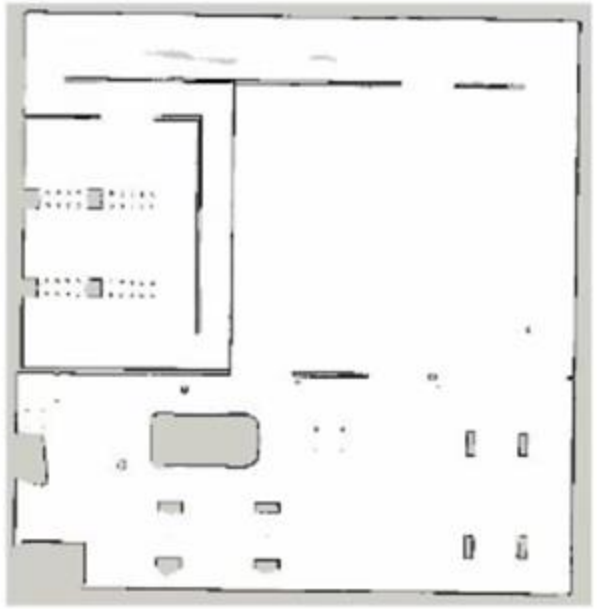
Cartographer 2D

Pros:

- Automatically save the map and generate .yaml file.

Cons:

- Fail to detect some 3D objects

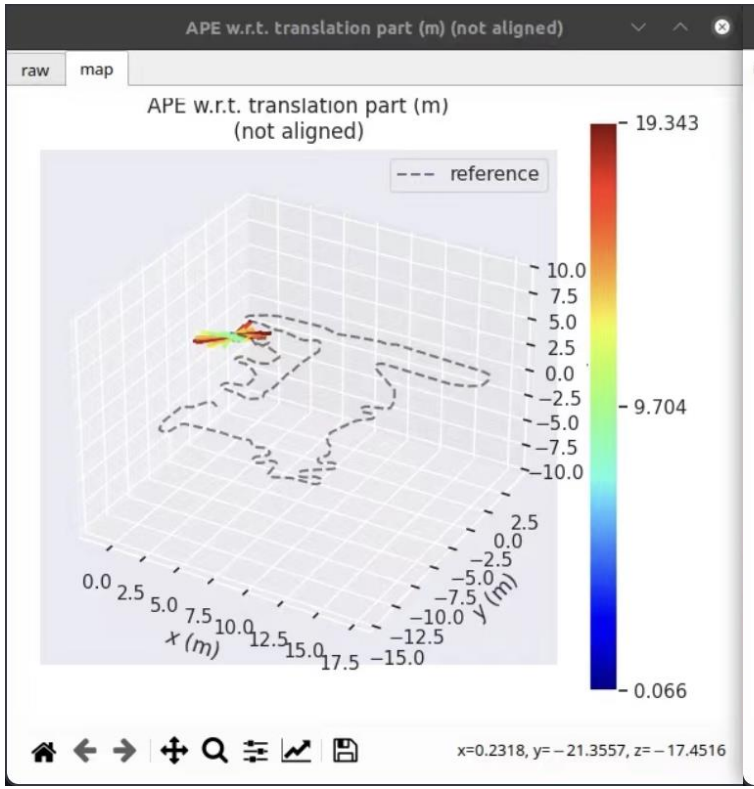


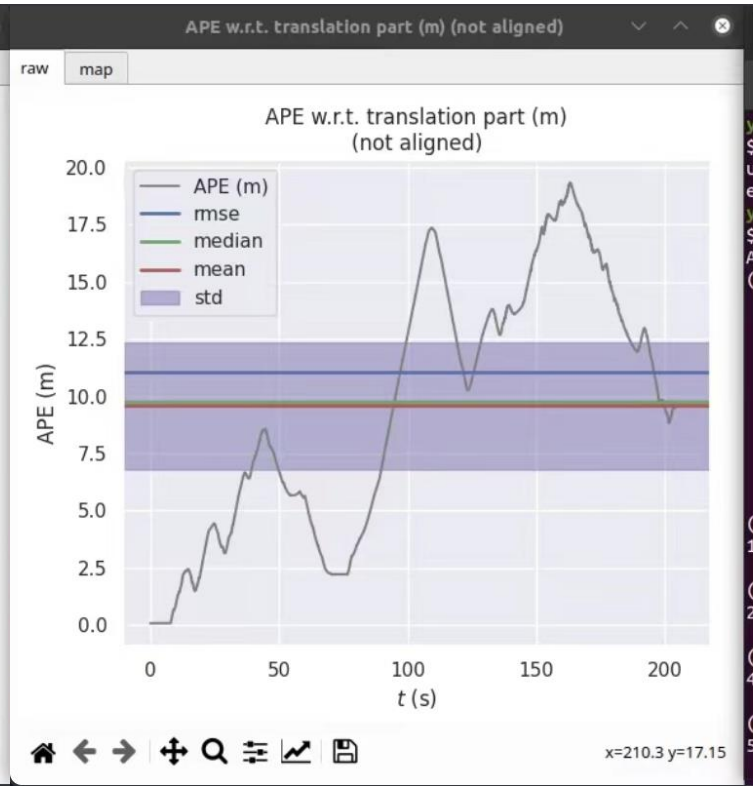
(a) Cartographer Result

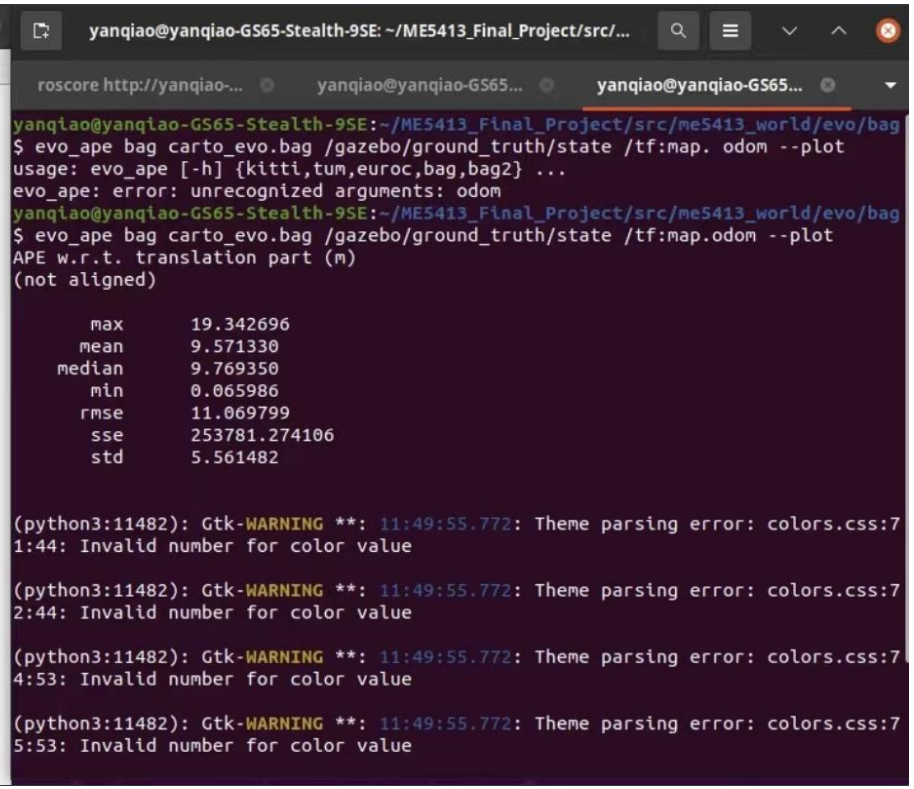
(b) Map Result

Cartographer 2D

EVO Evaluation:







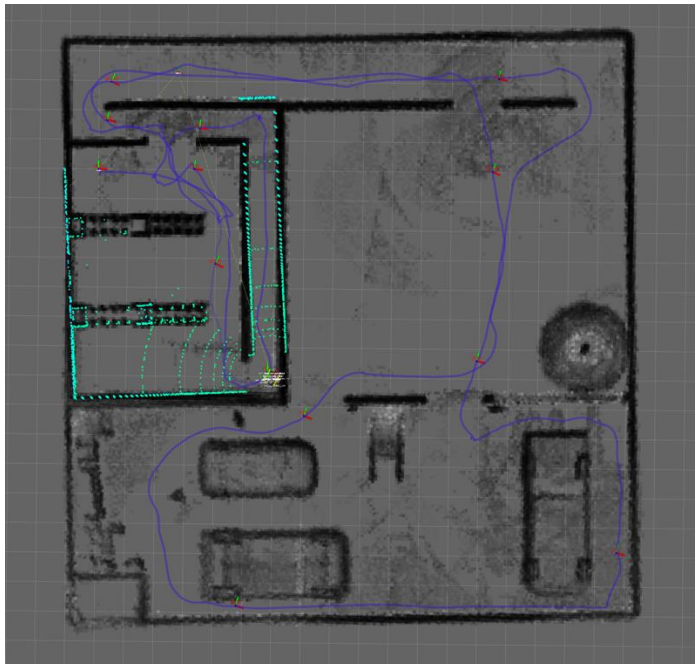
Cartographer 3D

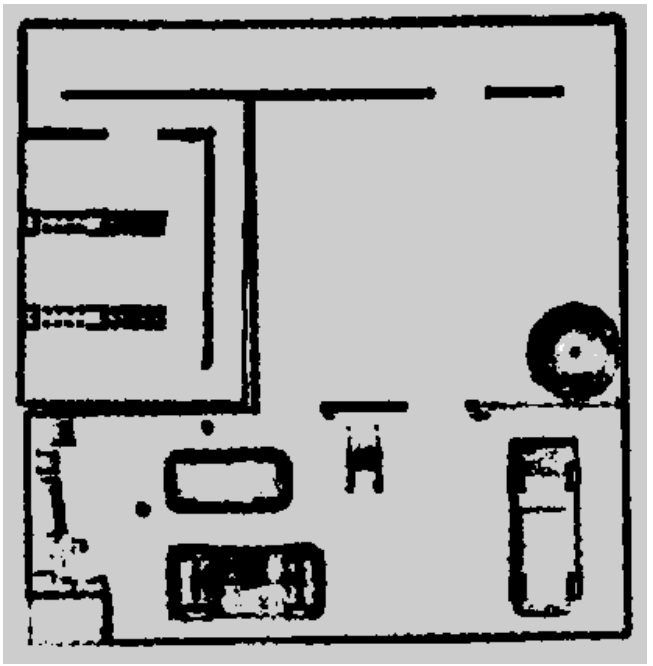
Pros:

- Automatically save the map and generate .yaml file.
- Can detect 3D object

Cons:

- Computational expensive
- Noisy and low resolution





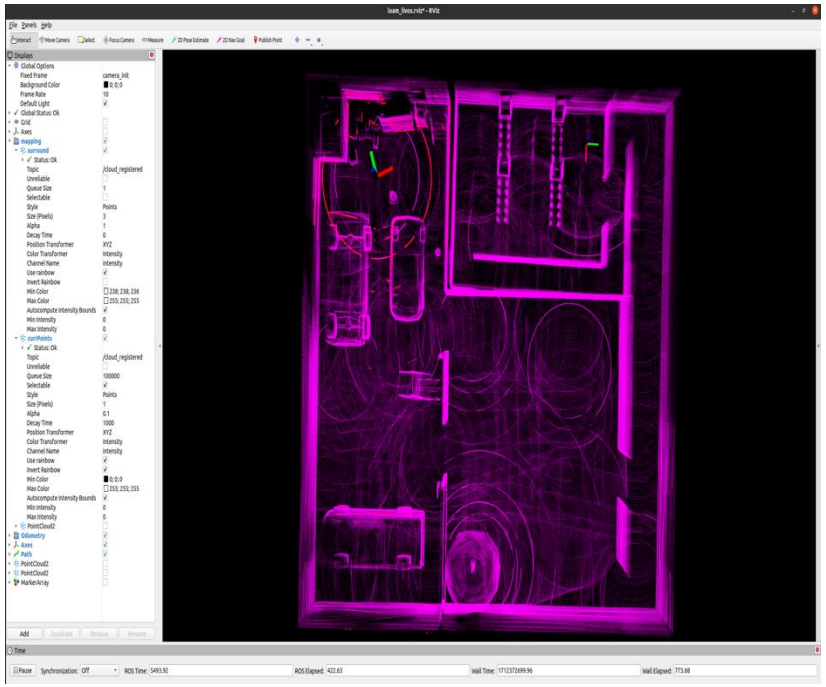
Fast-lio

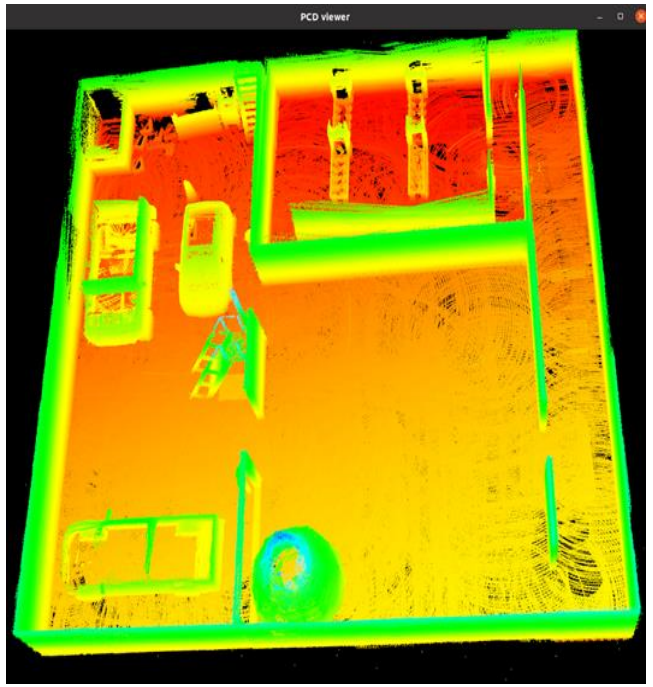
Pros:

- All necessary details detected
- Detection accurate enough for navigation

Cons:

- Require subsequent processing for the generated pcd map
- Noisy existed
- Require high PC performance





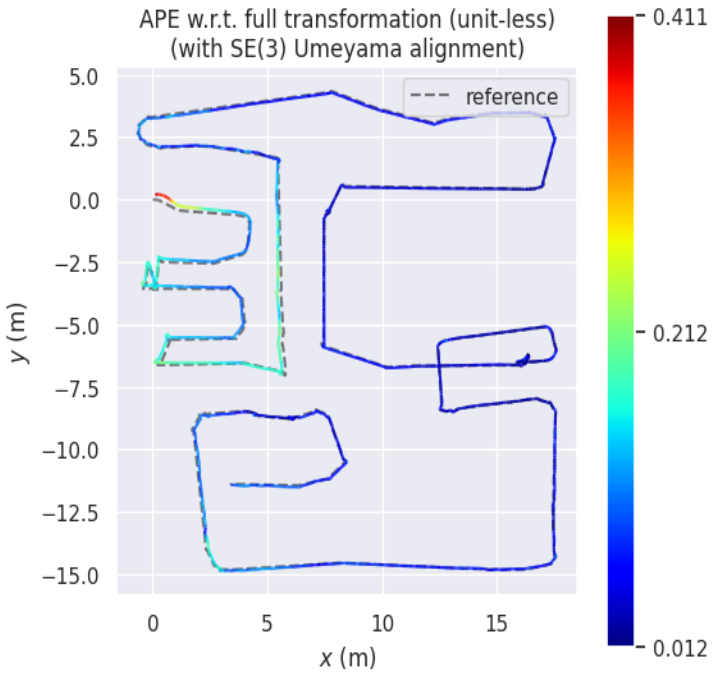
Fast-lio

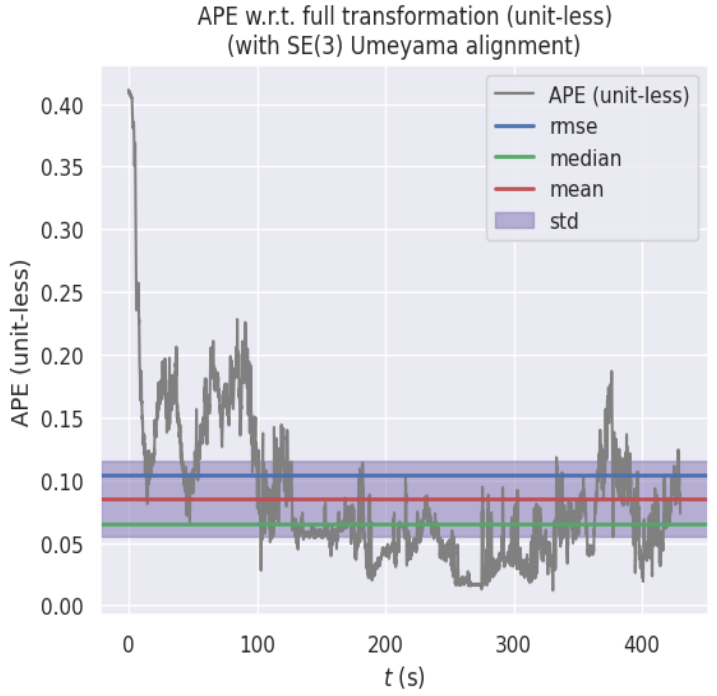
EVO Evaluation

```
chronobreak@chronobreak: ~
[[ 0.99943271  0.03314976  0.005946  ]
 [-0.03320965  0.99939561  0.01027286]
 [-0.00560186 -0.0104645   0.99992955]]
Translation of alignment:
[ 0.16496905  0.22209466 -0.23090588]
Scale correction: 1.0
---------------------------------------------------------------------------
Compared 4299 absolute pose pairs.
Calculating APE for full transformation pose relation...
---------------------------------------------------------------------------
APE w.r.t. full transformation (unit-less)
(with SE(3) Umeyama alignment)

       max      0.411339
      mean      0.085073
    median      0.065478
       min      0.011996
      rmse      0.104292
       sse      46.759873
       std      0.060328

---------------------------------------------------------------------------
Plotting results...
```





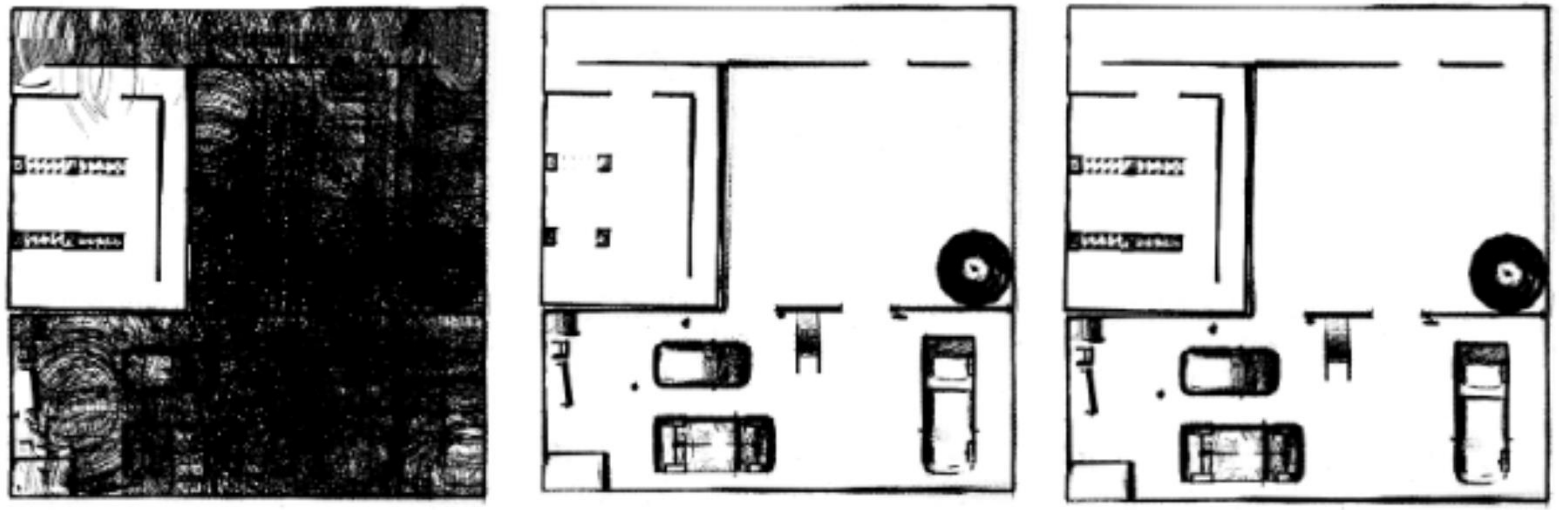
Fast-lio: Covert 3D map to 2D

Problem:

Large ground noises

Solution:

Apply a passthrough filter on the Z axis, set different filter limits.



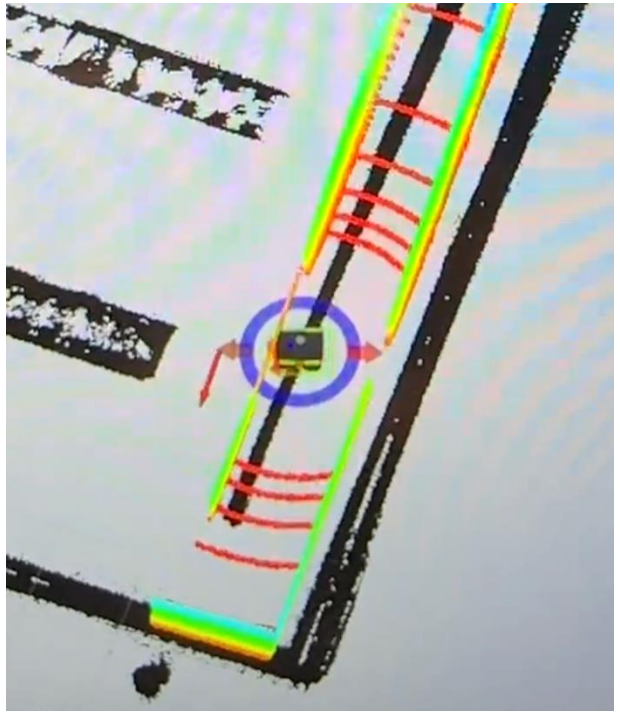
(a) Filter limit 0.45-inf (b) Filter limit 1-inf (c) Combined map

Task 2: Planning

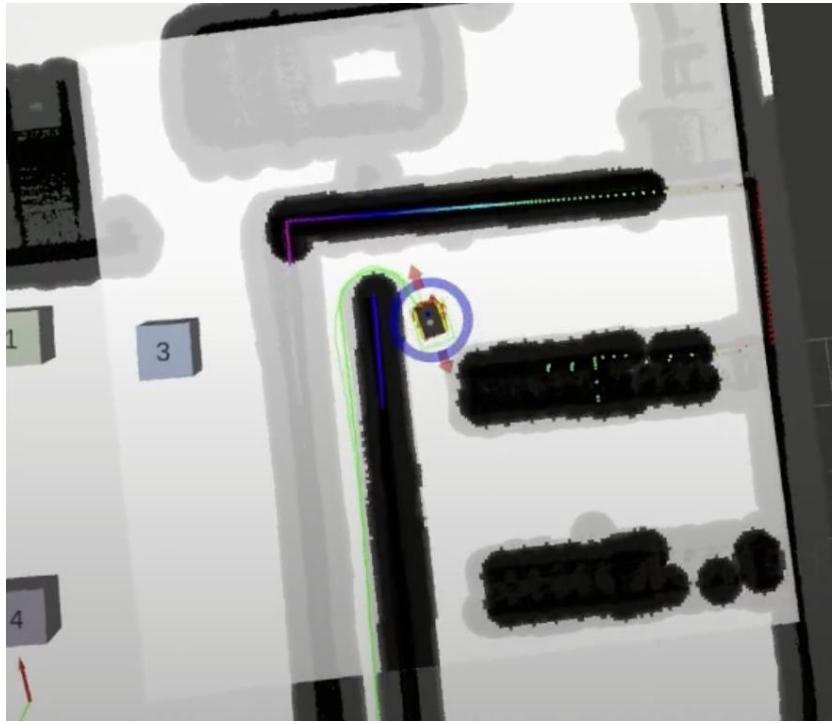
- Move base
- Improve odometry by modifying EKF
- Virtual wall

Move Base

- Only static layer
- Basic local planner



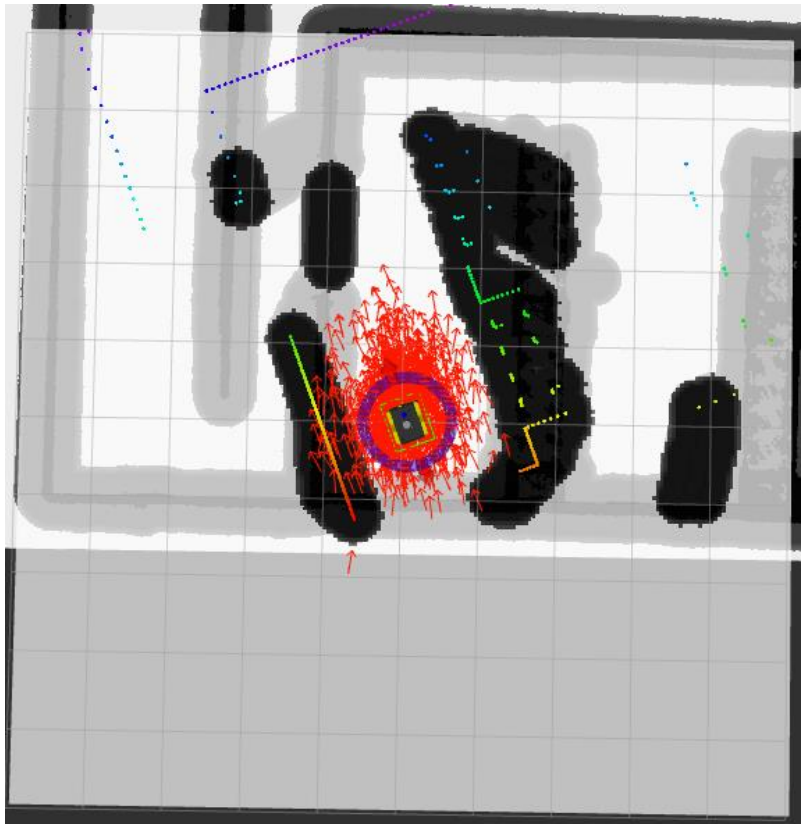
- Add inflation and obstacle layers
- Teb local planner



Improve odometry by modifying EKF

```
odom0: /jackal_velocity_controller/odom
odom0_config: [false, false, false,
               false, false, false,
               true, true, true,
               false, false, true,
               false, false, false]
odom0_differential: false

imu0: /imu/data
imu0_config: [false, false, false,
              true, true, false,
              false, false, false,
              true, true, true,
              false, false, false]
imu0_differential: false
```



Improve odometry by modifying EKF

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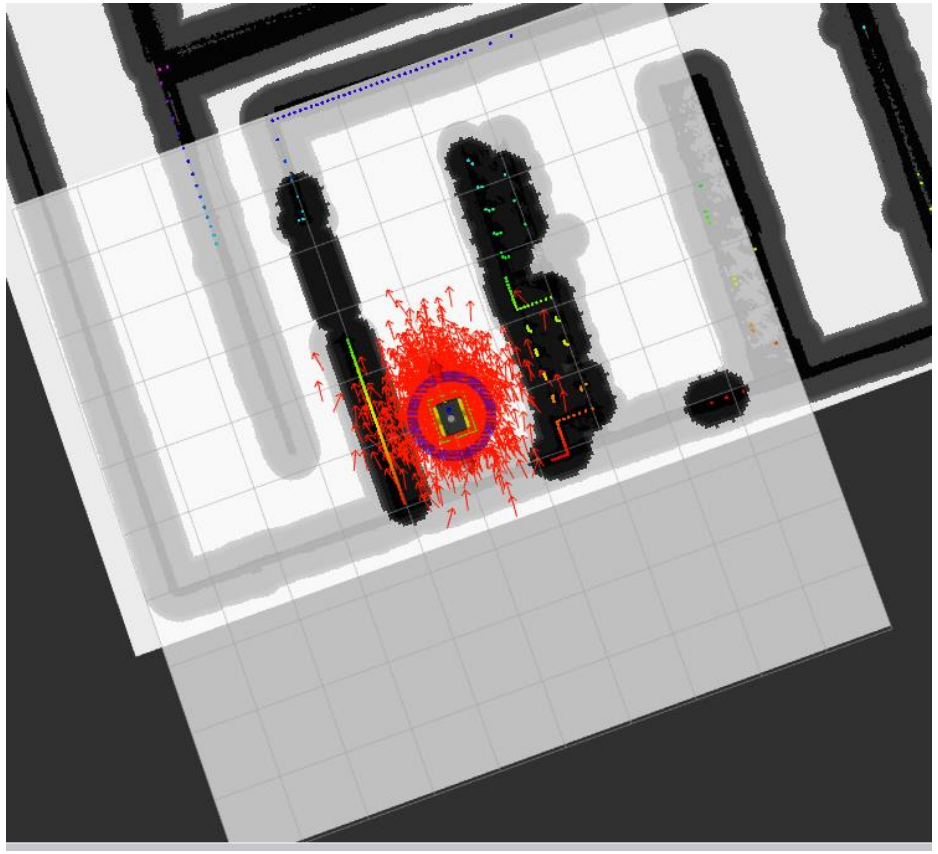
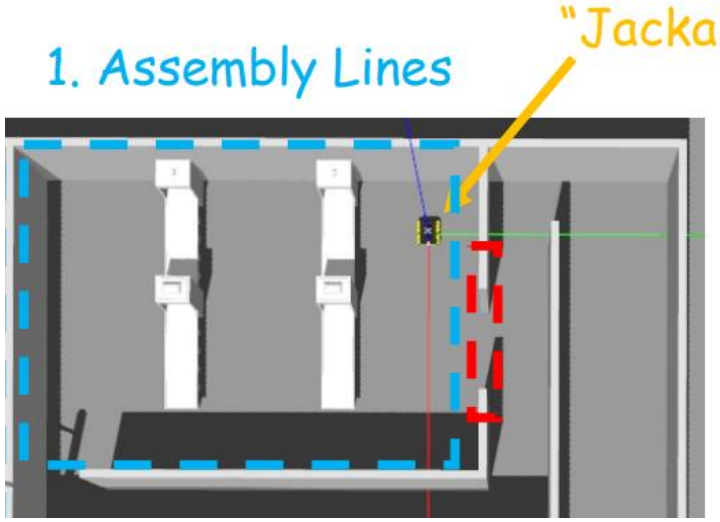
odom0: /jackal_velocity_controller/odom
odom0_config: [false, false, false,
               true, true, true,
               true, true, true,
               false, false, false,
               false, false, false]
odom0_differential: true

imu0: /imu/data
imu0_config: [false, false, false,
              false, false, true,
              false, false, false,
              false, false, true,
              true, true, false]
imu0_differential: true
```



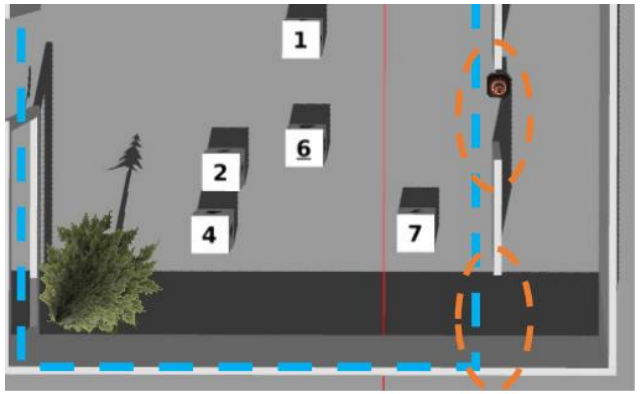
Virtual Wall

Due to the task requirements, there are restricted areas on the map.



Exit of assembly lines area

No shortcuts allowed

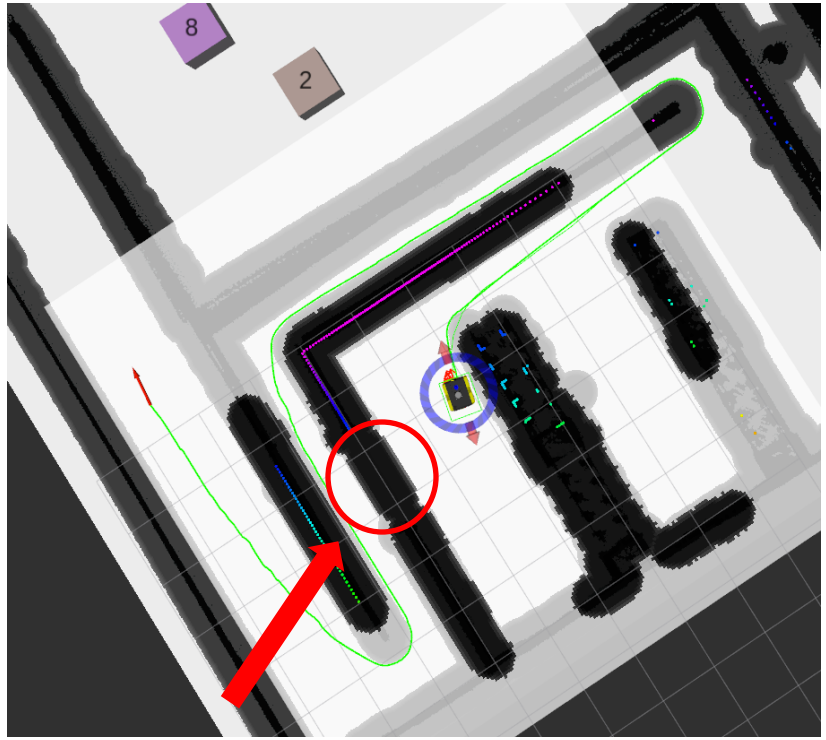


Entrance of random boxes area

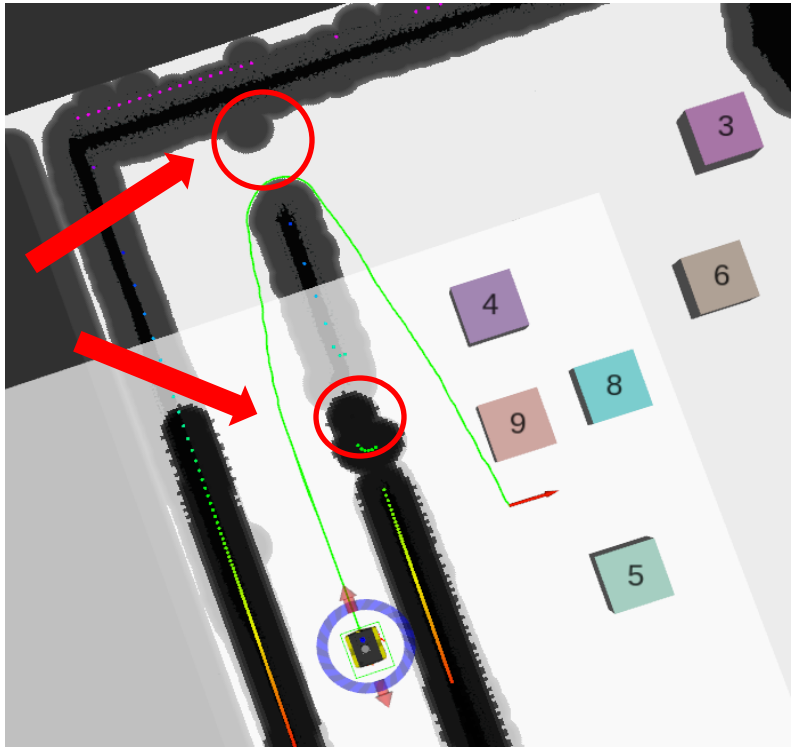
Only one allowed

Virtual Wall

Add the prohibition_layer parameter in the costmap files.



Prohibited line area



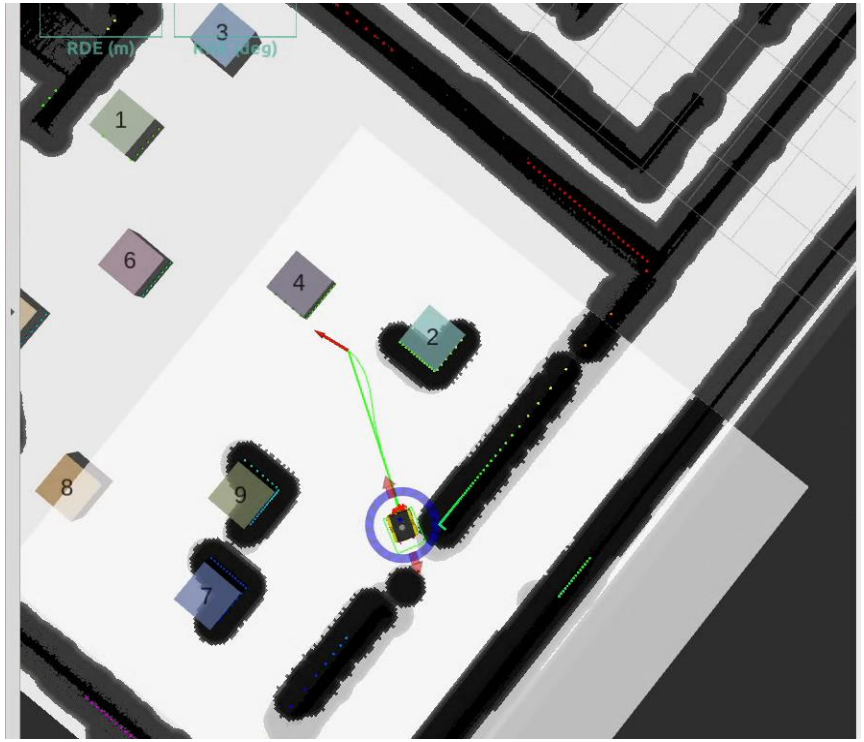
Prohibited point area

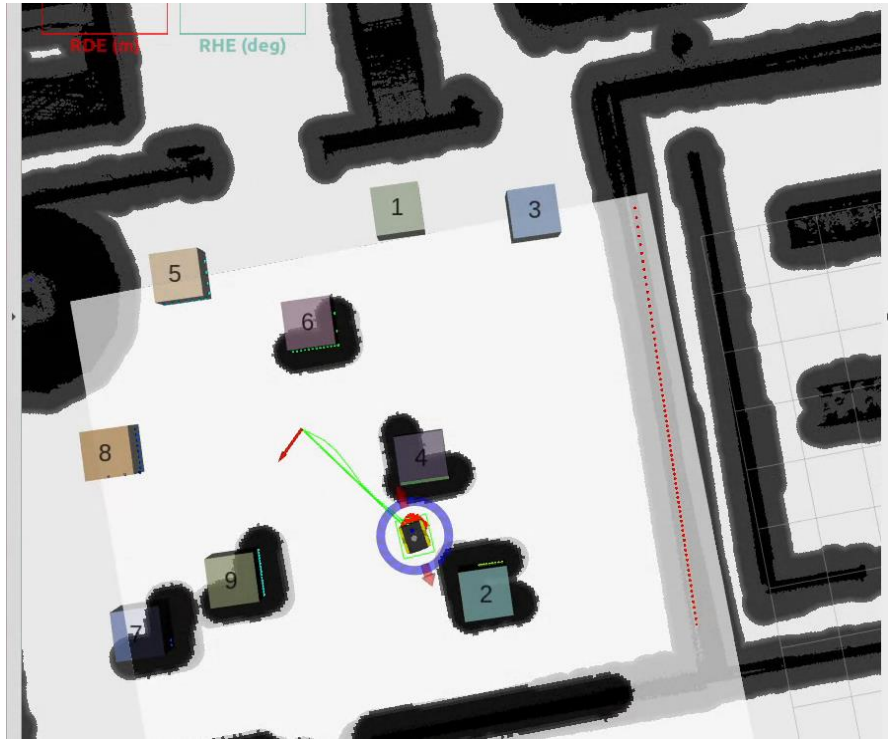
Task 3: Perception

- Random Patrols
- Object Detection
- Target Position Estimation
- Add Kinect
- Communication Problems
- Evaluation

Random Patrols

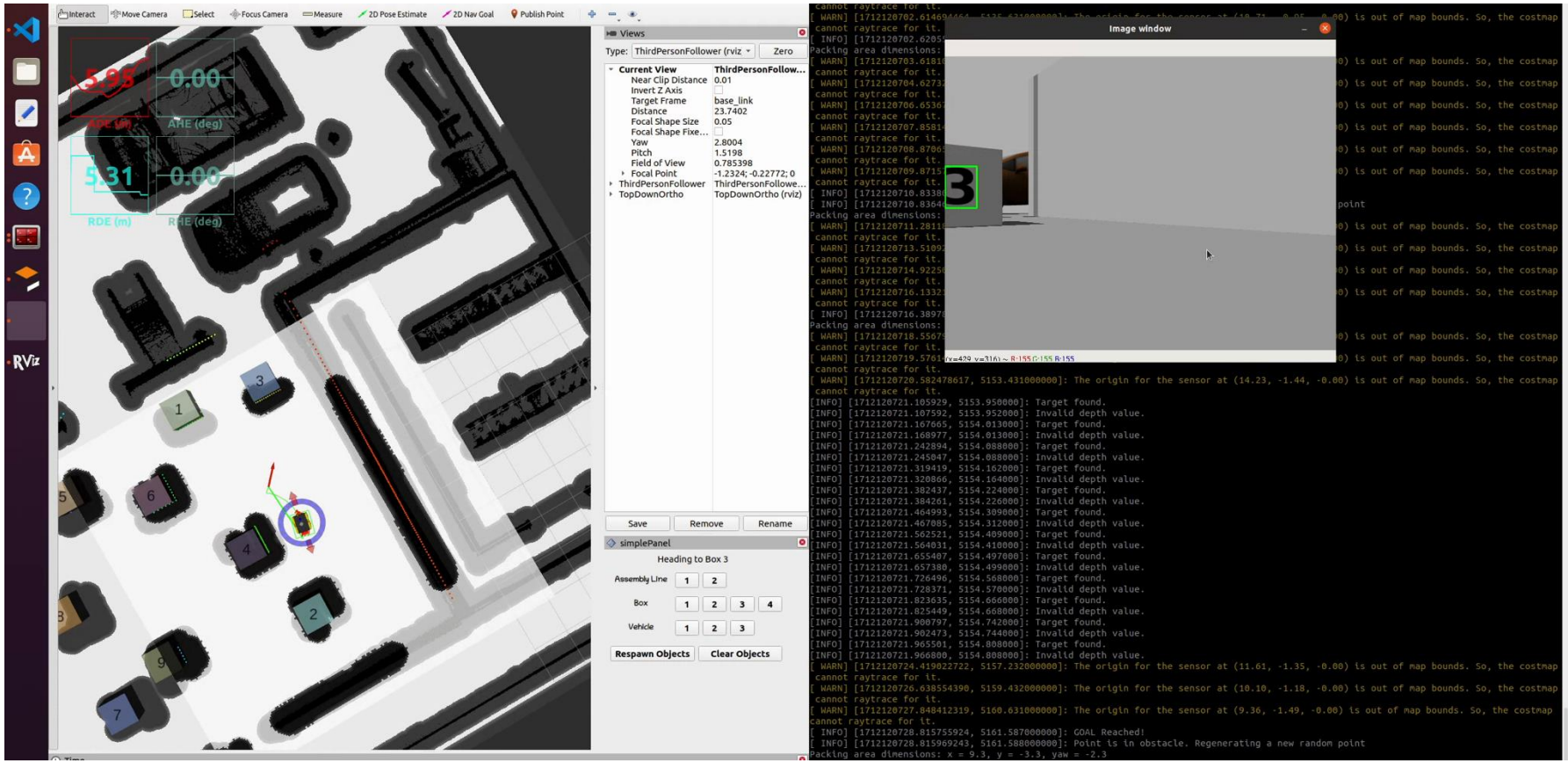
After reaching the former random goal, a new random one is generated





Object Detection

A simple template match is enough for simulation environment.



Target Position Estimation

- Calculation Theory

The position matrix from target to map ${}^{target}T_{map}$ is represented by:

$${}^{target}T_{map} = {}^{target}T_{optical} \cdot {}^{optical}T_{map}$$

For ${}^{optical}T_{map}$, it is easy to obtain from tf listener.

For ${}^{target}T_{optical}$, the following functions are used to calculate:

$$X = \frac{(u - c_x) \cdot Z}{f_x}$$

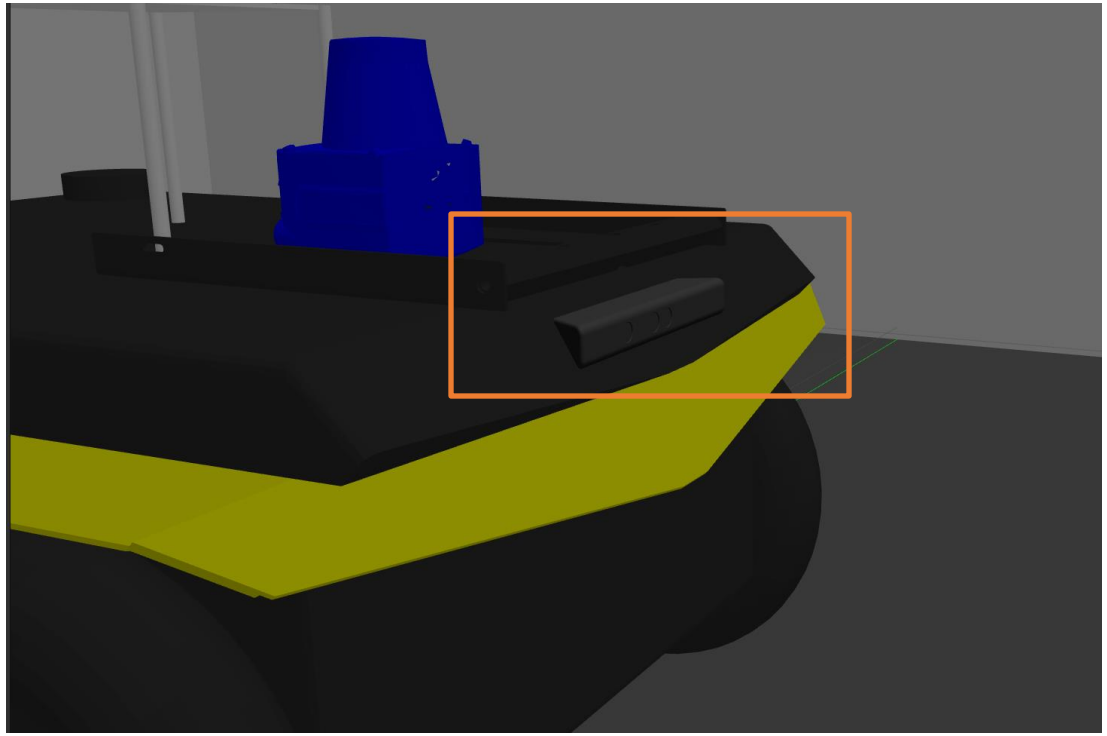
$$Y = \frac{(v - c_y) \cdot Z}{f_y}$$

$$Z = Z$$

Target Position Estimation

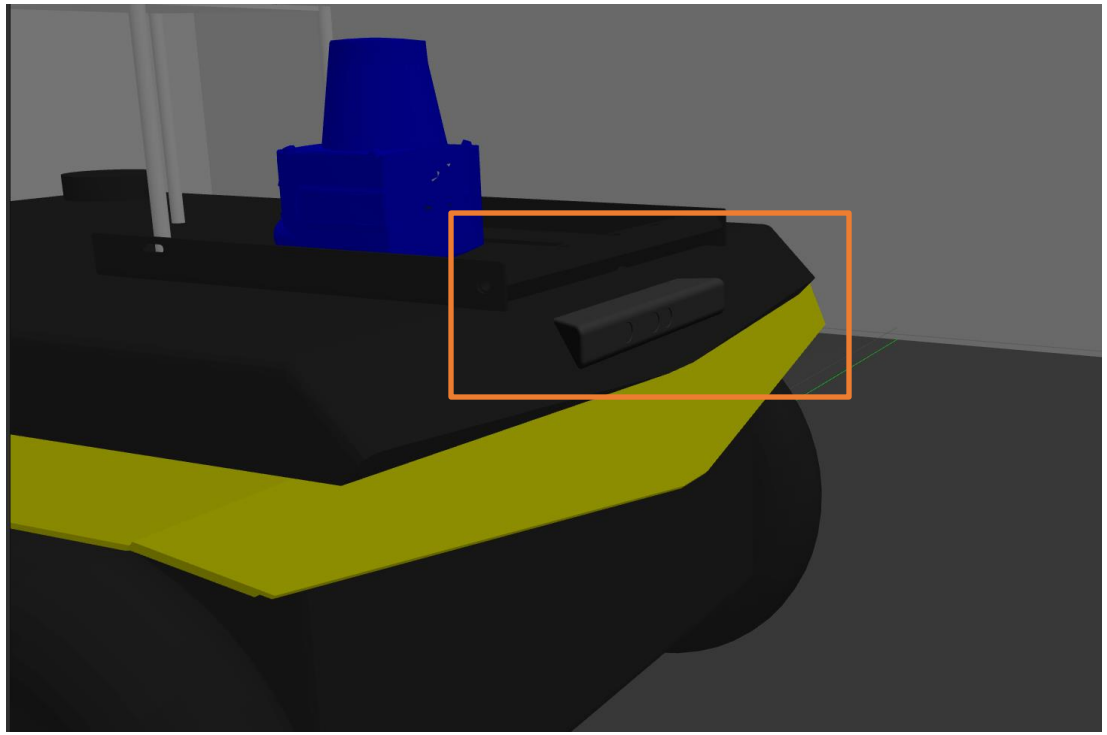
- Add Kinect

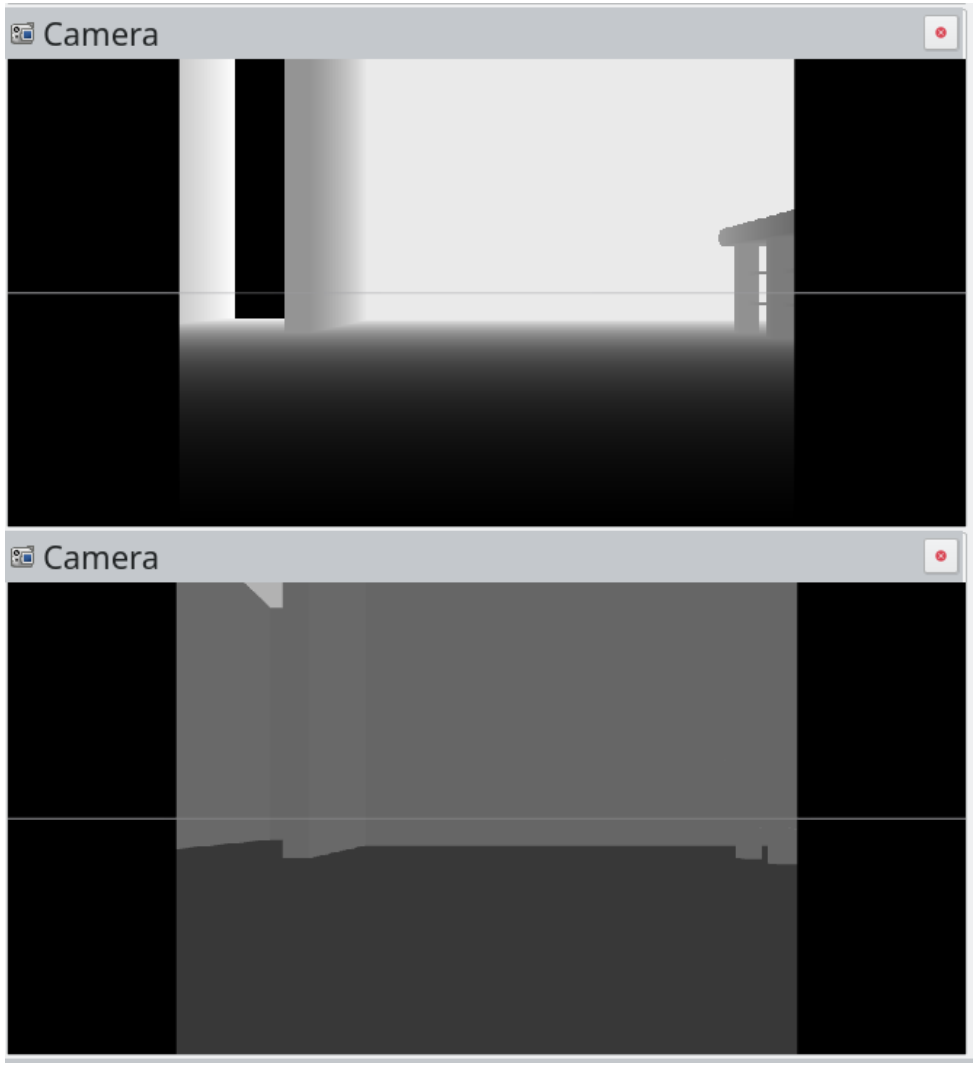
We modified urdf to add Kinect depth camera on the front of robot



Target Position Estimation

- Add Kinect

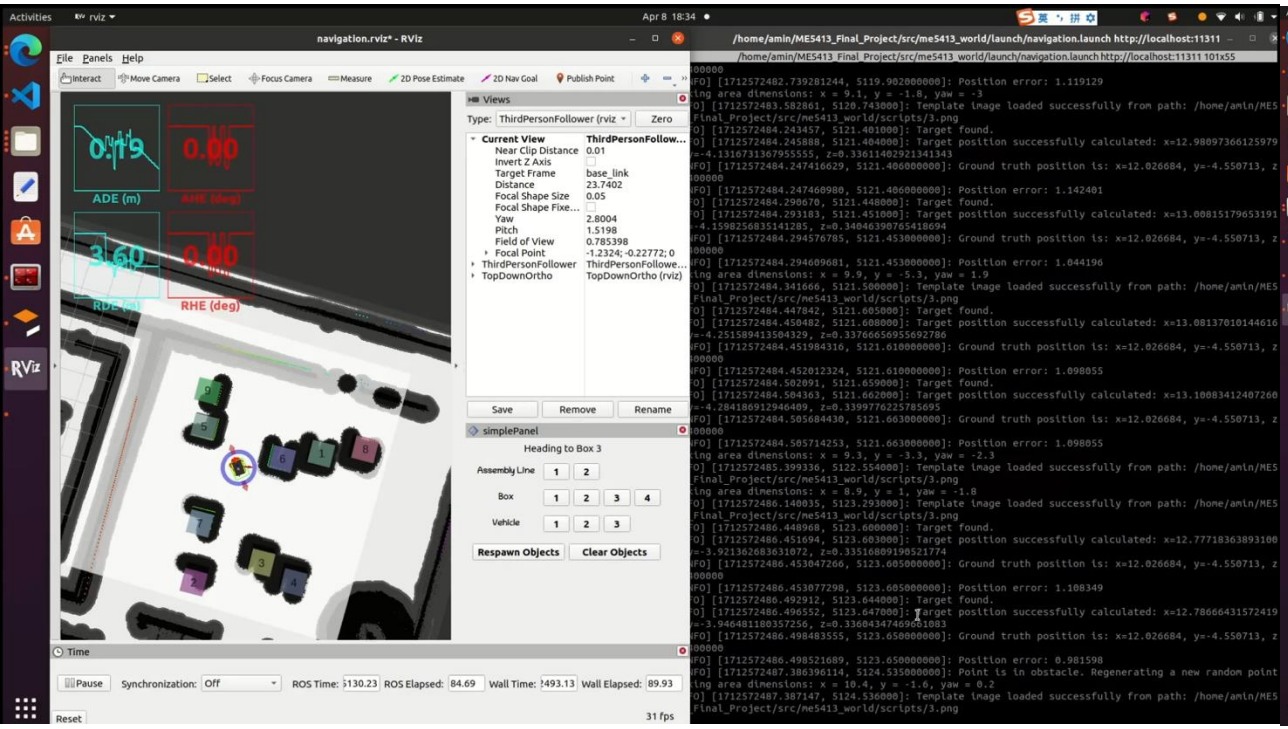


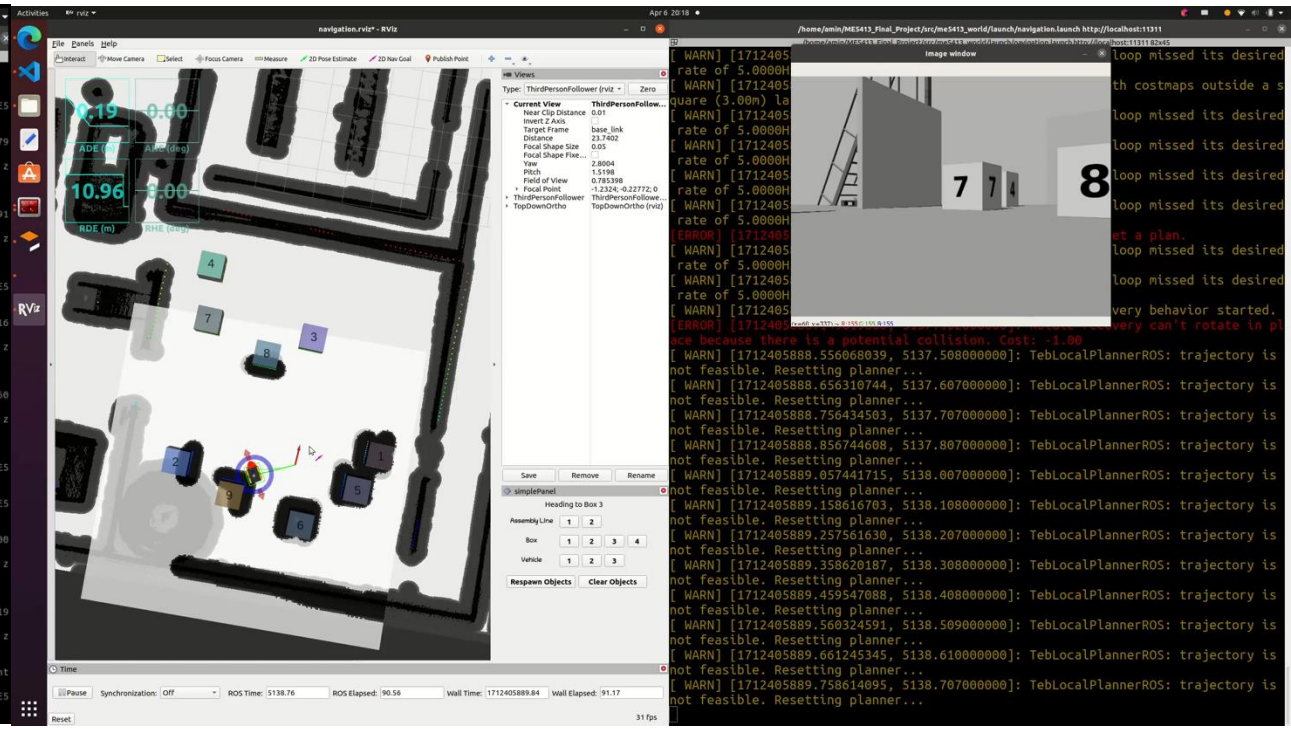


Communication Problems

Move base sends the topic many times for one status reached.

RGB image, depth image, and ego pose, are not input simultaneously.





Evaluation

The position estimation results perform well! The average error for each experiment is under or equal to 1.3 meter!

Experiment	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Iteration 5	Average
First	1.13	1.43	1.47	1.27	1.21	1.30
Second	1.12	1.10	1.60	1.41	0.94	1.23
Third	0.85	1.32	1.00	1.24	1.40	1.16

Table 1: Error table for perception task experiments. All data in meters.

Thank You