RANSAC TEST REPORT

This is a test report of plane detection in 3D point cloud space. The test algorithms are optimized RANSAC of our team and RANSAC of PCL(Point Cloud Library).

Environment

> OS: Ubuntu 18.04.5 LTS x86_64
> Kernel: 4.15.0-140-generic
> CPU: Intel Xeon Gold 6278C (2) @ 2.600GHz
> Memory: 248MiB / 3944MiB

Dataset

`Z0-Z4` , `Cassette` datasets are obtained from IQmulus & TerraMobilita Contest, download link: Zones 0-4 , Cassette_idclass.zip.

`check` dataset has 1,000,000 points generated by functions `y+z=0` , `y+z-80=0` and `y+z+80=0` and 10,000 noise points randomly.

`std_cube` is a standard cube generated by blender model has 15608 points in total.

Note that PCL does not support point cloud data of double type. We need to modify the point cloud data file header, change `property double` to `property float`.

Dataset	Point Cloud Size
Z0	13653854
Z1	12128400
Z2	13685800
Z3	9783553
Z4	16693019
Cassette	12000000
check	1010000
std_cube	15608

Note: In table header, `Dt` is the abbreviation of `dataset`, `MI` is the abbreviation of `Max Iterations`.

Result

Single plane detection

> Parameters:
>
> - Dataset: Z0, Z1, Z2, Z3, Z4, Cassette
> - Desired_num_planes: 1
> - Threshold: 0.5
> - Grid Size: 0.22*0.22*0.22

Optimized RANSAC test results:

Dt	MI	Output Plane	inliers num	Time Cost (s)	Fig.
Z0	1200	0.009483x + 0.011083y + 0.999894z + -291.418945 = 0	4830340	7.091351	T1_Z0
Z0	2000	0.009483x + 0.011083y + 0.999894z + -291.418945 = 0	4830340	7.071982	T1_Z0
Z1	1200	0.018050x + -0.012168y + -0.999763z + 260.978027 = 0	3801026	6.876662	T1_Z1
Z1	2000	0.018050x + -0.012168y + -0.999763z + 260.978027 = 0	3801026	7.418779	T1_Z1
Z2	1200	0.000464x + -0.012077y + -0.999927z + 293.274048 = 0	4845657	10.395679	T1_Z2
Z2	2000	0.000464x + -0.012077y + -0.999927z + 293.274048 = 0	4845657	12.613471	T1_Z2
Z3	1200	0.007012x + 0.004261y + -0.999966z + -73.049179 = 0	3512145	4.675437	T1_Z3
Z3	2000	0.007012x + 0.004261y + -0.999966z + -73.049179 = 0	3512145	4.796984	T1_Z3
Z4	1200	0.002536x + -0.013457y + -0.999906z + 318.325714 = 0	6809790	11.775782	T1_Z4
Z4	2000	0.002536x + -0.013457y + -0.999906z + 318.325714 = 0	6809790	11.990440	T1_Z4
Cassette	1200	0.998271x + 0.058538y + 0.005261z + -3145.417236 = 0	3314531	5.401879	T1_Ca
Cassette	2000	0.998271x + 0.058538y + 0.005261z + -3145.417236 = 0	3314531	5.396362	T1_Ca

Table 1. Optimized RANSAC test results

PCL RANSAC test results:

Dt	MI	Output Plane	inliers num	Time Cost (s)	Fig.
Z0	1200	-0.007703x + -0.013446y + -0.999880z + 337.664459 = 0	4670605	22.114613	T2_Z0
Z0	2000	-0.007703x + -0.013446y + -0.999880z + 337.664459 = 0	4670605	22.108990	T2_Z0
Z1	1200	0.007207x + -0.009169y + -0.999932z + 218.550339 = 0	3412594	36.879353	T2_Z1
Z1	2000	0.007207x + -0.009169y + -0.999932z + 218.550339 = 0	3412594	36.810921	T2_Z1
Z2	1200	0.017990x + -0.012385y + -0.999761z + 263.990479 = 0	4707855	21.760893	T2_Z2
Z2	2000	0.017990x + -0.012385y + -0.999761z + 263.990479 = 0	4707855	21.749063	T2_Z2
Z3	1200	0.003711x + 0.004773y + -0.999982z + -77.222191 = 0	3398112	18.284340	T2_Z3
Z3	2000	0.003711x + 0.004773y + -0.999982z + -77.222191 = 0	3398112	18.244528	T2_Z3
Z4	1200	0.003726x + -0.015072y + -0.999879z + 350.359467 = 0	6843592	15.747861	T2_Z4
Z4	2000	0.003726x + -0.015072y + -0.999879z + 350.359467 = 0	6843592	15.714494	T2_Z4
Cassette	1200	-0.015456x + 0.000261y + 0.999880z + -14.493980 = 0	4577838	13.985825	T2_Ca
Cassette	2000	-0.015456x + 0.000261y + 0.999880z + -14.493980 = 0	4577838	13.977005	T2_Ca

Table 2. PCL RANSAC test results

> Parameters:
>
> - Dataset: check, std_cube
> - Desired_num_planes: 1
> - Threshold: 0.2
> - Grid Size: 0.2*0.2*0.2

Optimized RANSAC test results:

Dt	MI	Output Plane	inliers num	Time Cost (s)	Fig.
check	1200	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	1.506872	ck1
check	2000	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	1.500934	ck1
std_cube	1200	0.000000x + 0.000000y + 1.000000z + -28.579615 = 0	2704	0.043189	T3_Cb
std_cube	2000	0.000000x + 0.000000y + 1.000000z + -28.579615 = 0	2704	0.059029	T3_Cb

Table 3. Optimized ransac test results

Optimized RANSAC without sampling test results:

Dt	MI	Output Plane	inliers num	Time Cost (s)	Fig.
check	1200	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	0.221905	ck1
check	2000	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	0.224215	ck1

Table 4. Optimized ransac test results

PCL RANSAC test results:

Dt	MI	Output Plane	inliers num	Time Cost (s)	Fig.
check	1200	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	0.313140	ck1
check	2000	0.000000x + 0.707107y + 0.707107z + -0.000000 = 0	600040	0.311617	ck1
std_cube	1200	0.000000x + 0.000000y + -1.000000z + 28.579617 = 0	2704	0.194111	T5_Cb
std_cube	2000	0.000000x + 0.000000y + -1.000000z + 28.579617 = 0	2704	0.195428	T5_Cb

Table 5. PCL ransac test results

Multiple plane detection

> Parameters:
>
> - Dataset: Z0, Z1, Cassette, check, std_cube
> - Desired_num_planes: 3
> - Threshold: 0.5
> - Max Iterations: 1000
> - Grid Size: 0.2*0.2*0.2

Dt	Output Plane	inliers num	Time Cost (s)	Fig.
Z0	0.004945x + 0.011472y + 0.999922z + -291.109344 = 0 -0.846692x + -0.531952y + -0.011818z + 12725.888672 = 0 -0.847184x + -0.530829y + -0.022347z + 12717.747070 = 0	4727444 2242023 2274777	11.188144	T6_Z0
Z1	0.018126x + -0.012115y + -0.999762z + 259.711945 = 0 0.998194x + -0.060069y + -0.001279z + -674.846924 = 0 0.998121x + -0.061206y + -0.002822z + -662.281738 = 0	3806217 2176059 2243760	9.633819	T6_Z1
Cassette	-0.998050x + -0.058789y + -0.020992z + 3150.989990 = 0 0.027402x + 0.005032y + 0.999612z + -197.133118 = 0 0.998156x + 0.060608y + -0.003293z + -3178.552490 = 0	3309048 4506258 1012761	7.744529	T6_Ca
check	0.000000x + 0.707107y + 0.707107z + 0.000000 = 0 0.000000x + 0.707107y + 0.707107z + 56.568542 = 0 0.000000x + 0.707107y + 0.707107z + -56.568539 = 0	600080 200039 200041	1.629339	ck3
std_cube	0.000000x + 0.000000y + 1.000000z + -28.579615 = 0 0.000000x + 0.000000y + 1.000000z + -103.548683 = 0 1.000000x + 0.000000y + 0.000000z + -37.484539 = 0	2704 2704 2600	0.082339	T6_Cb

Table 6.Optimized ransac multiple planes test results

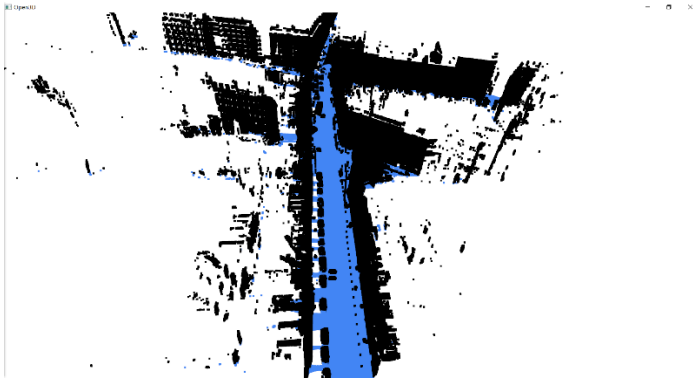

Fig. T1_Z0

Fig. T1_Z1

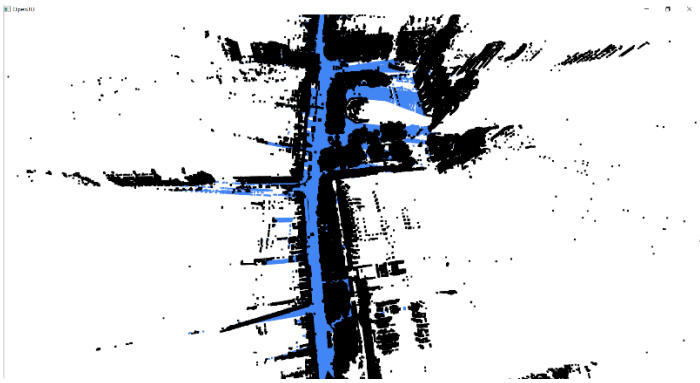

Fig. T1_Z2

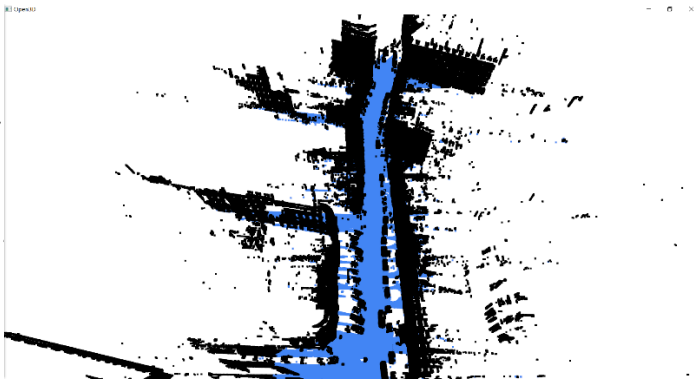

Fig. T1_Z3

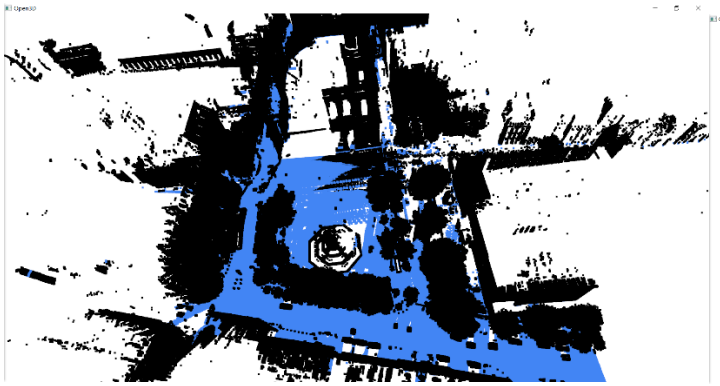

Fig. T1_Z4

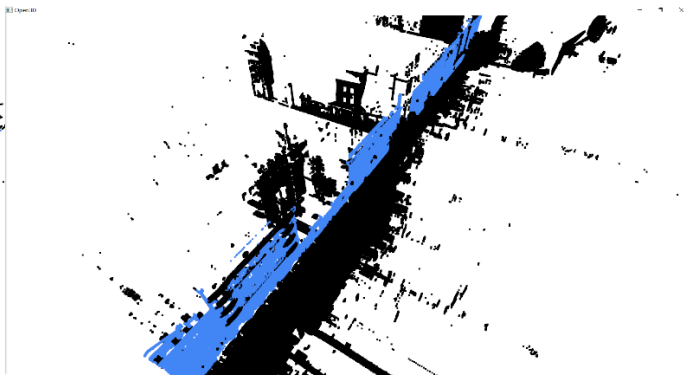

Fig. T1_Ca

Fig. T2_Z0

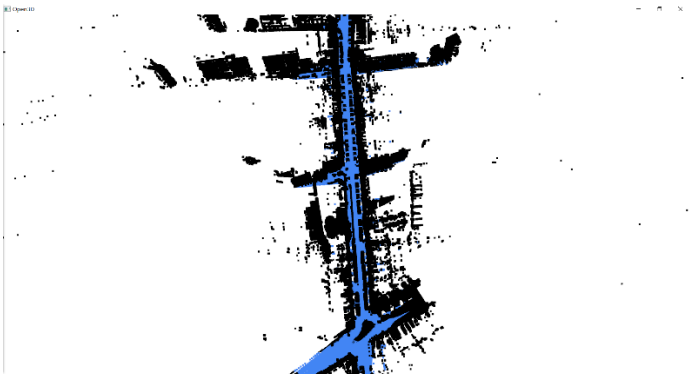

Fig. T2_Z1

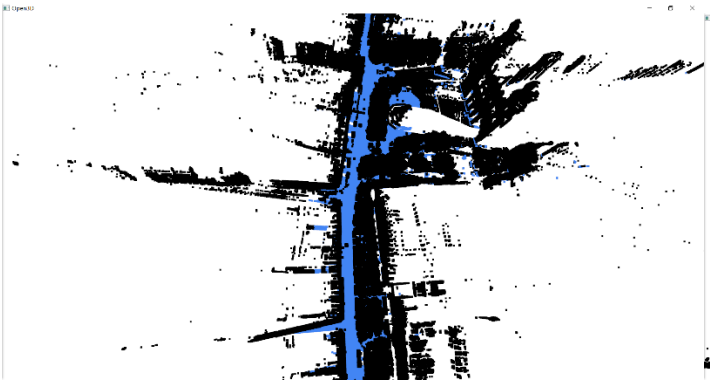

Fig. T2_Z2

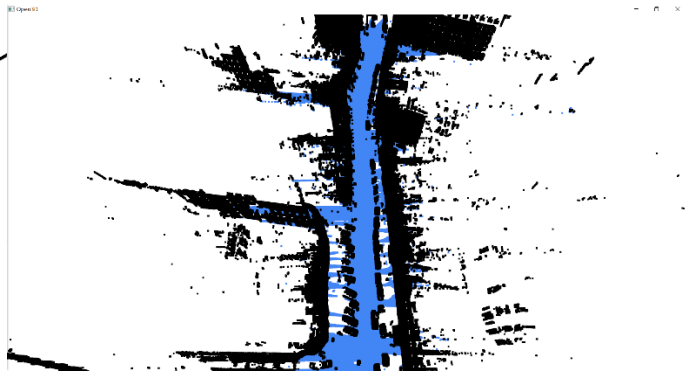

Fig. T2_Z3

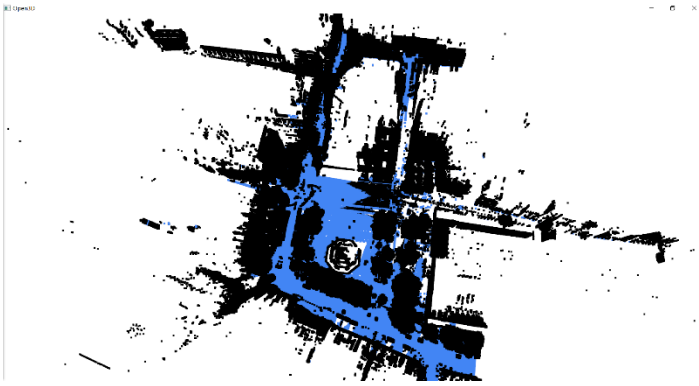

Fig. T2_Z4

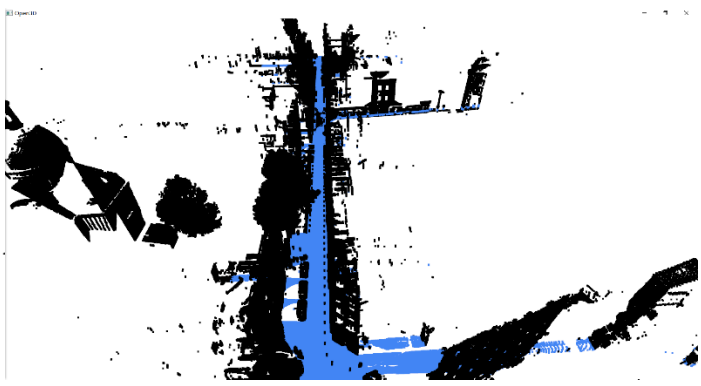

Fig. T2_Ca

Fig. ck1

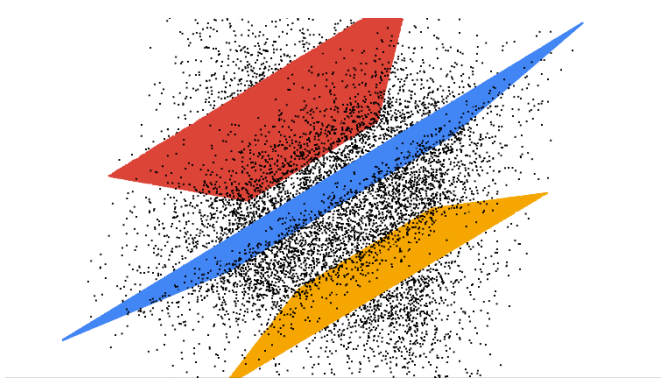

Fig. ck3

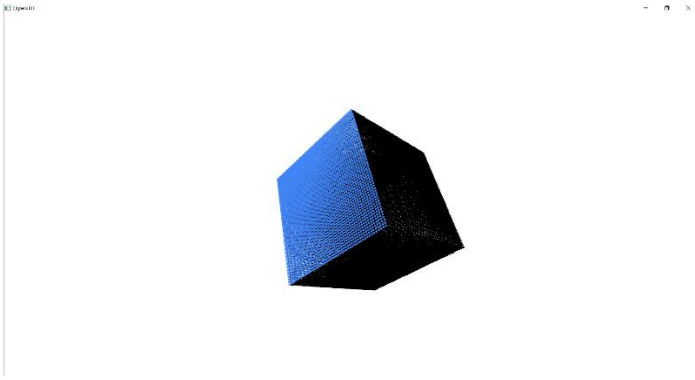

Fig. T3_Cb

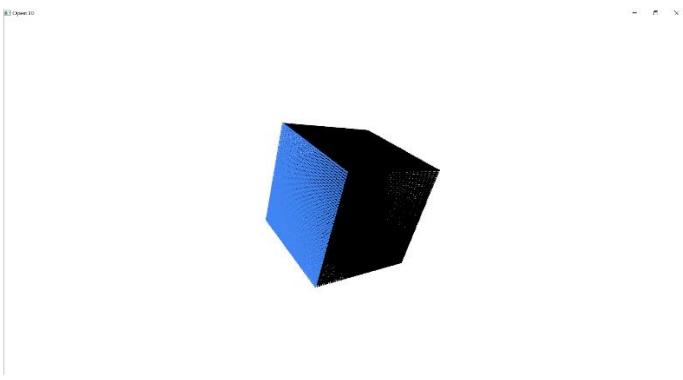

Fig. T5_Cb

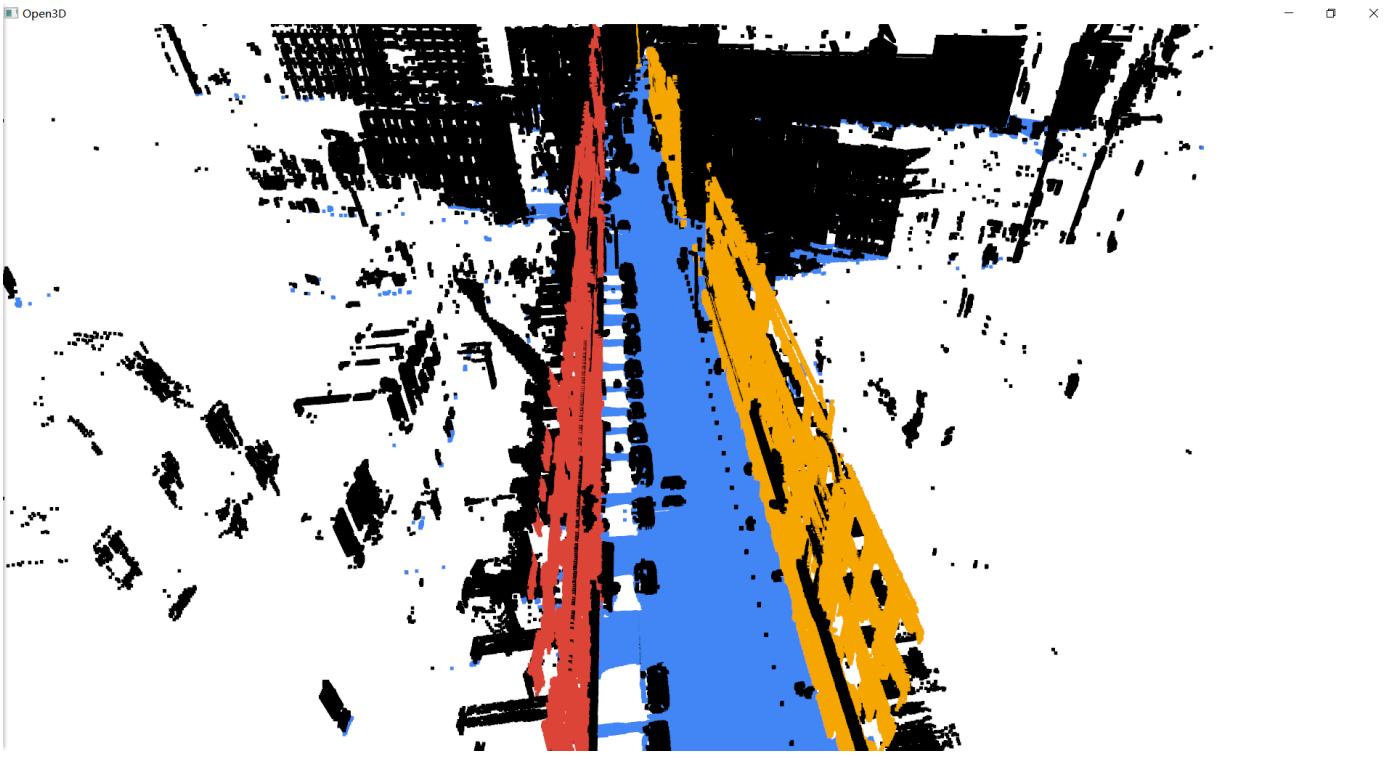

Fig. T6_Z0

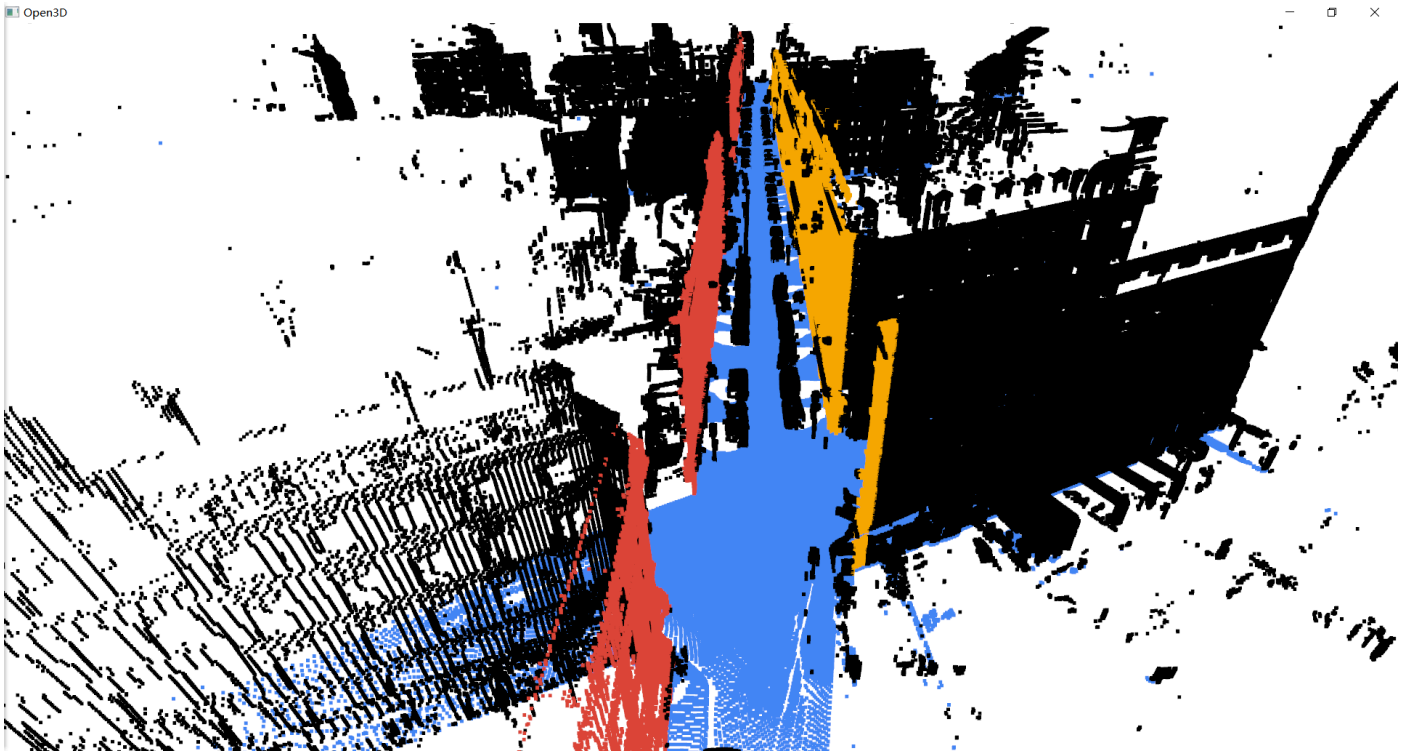

Fig. T6_Z1

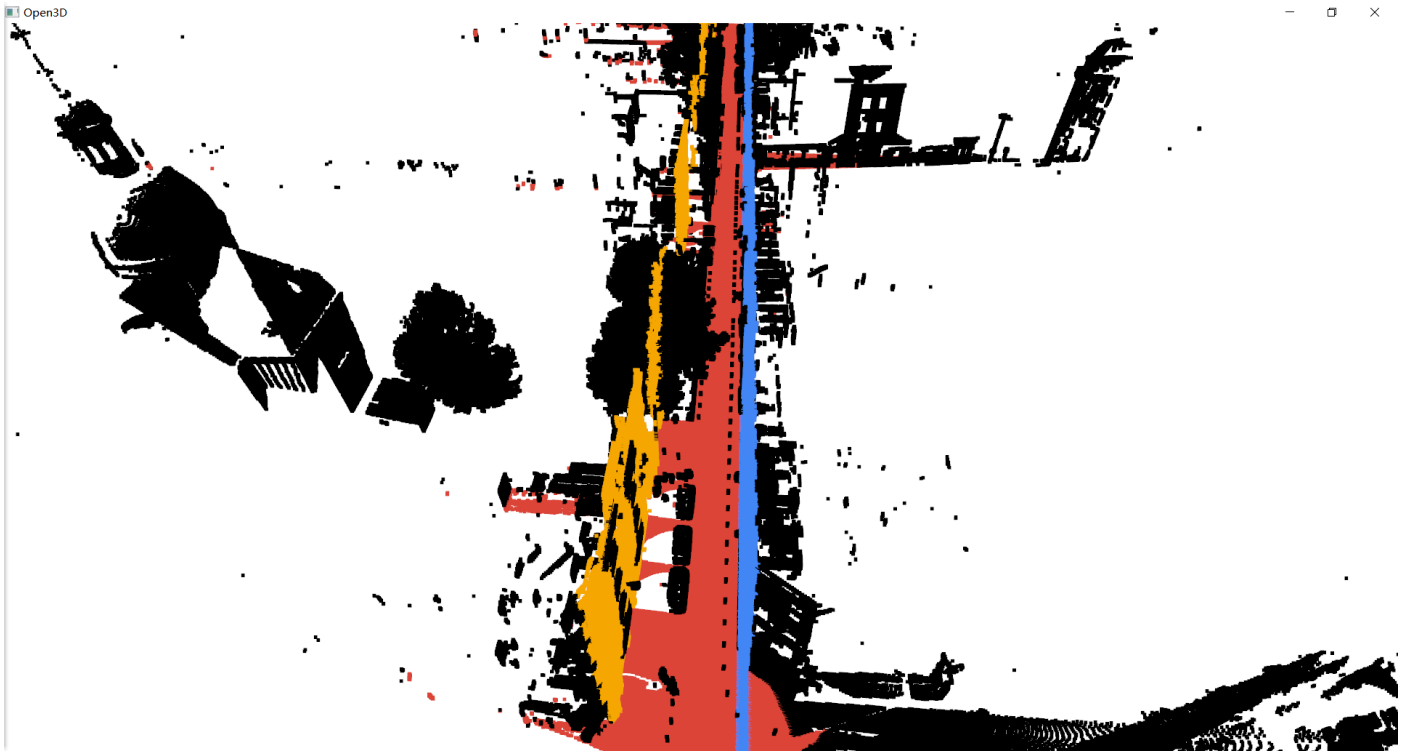

Fig. T6_Ca

Conclusion

Our Optimized RANSAC algorithm has the following advantages:

- It has good speed and accuracy generally.
- It can detect multiple planes at one time.
- User can choose whether to use sampling to preprocess the point cloud.

For voxel filtering, it speeds up the speed of plane detection in the point cloud, and it is more effective and intuitive to detect multiple planes. However, it also has the following problems:

- When the point cloud is small and only a small number of planes are detected, the time-consuming proportion of sampling is large, which weakens its effect.
- For non-uniform point clouds, voxel filtering can not guarantee the proportion of points between planes, which may lead to the inconsistency between the best plane model after sampling and that before sampling.