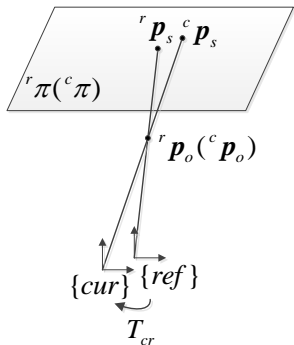


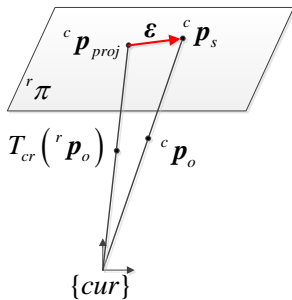
# Plane Feature and Projective Shadow based SLAM

Sun Qinxuan

June 30, 2017



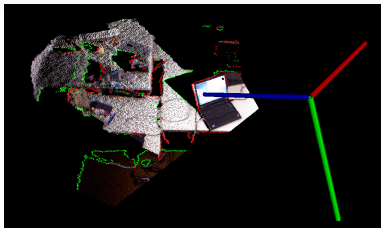
$T_{cr} = 0$



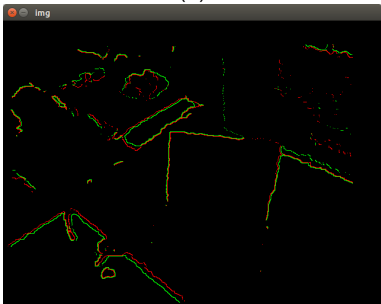
## Shadow point extraction



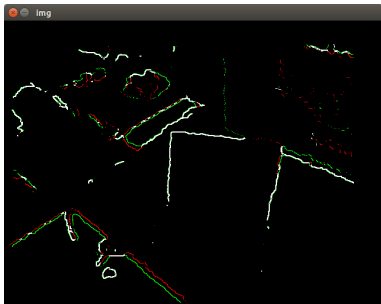
(a)



(b)



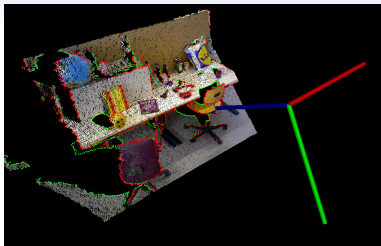
(c)



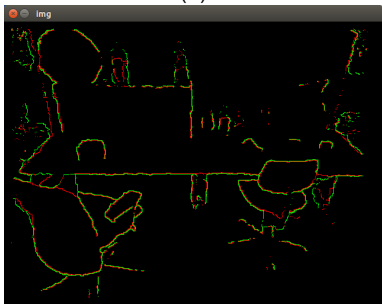
(d)



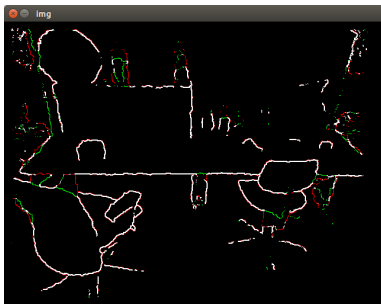
(a)



(b)



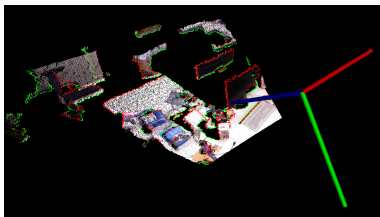
(c)



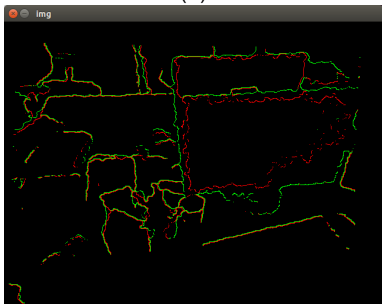
(d)



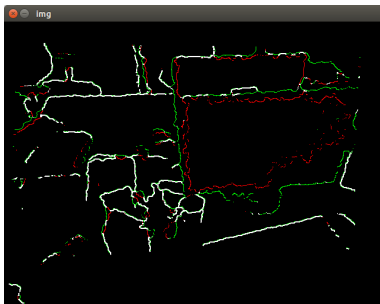
(a)



(b)



(c)

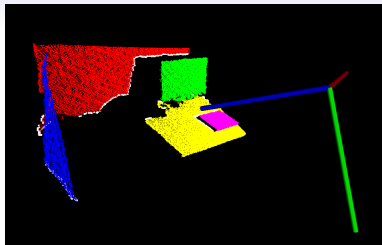


(d)

## Shadow point weighting — 6DoF case



(a)



(b)

```
H_singularValues ---
2.34828 1.65432 0.99723
H_svd_U ---
0.196086 -0.18783 0.962429
0.309457 0.943181 0.121024
0.930477 -0.274099 -0.24307
H_svd_V ---
0.231686 -0.240971 0.942473
0.322836 0.932973 0.15918
0.917659 -0.267385 -0.293951
```

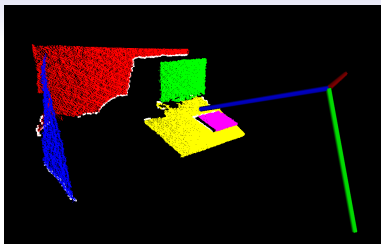
(c)

Figure:





(a)



(b)

```

Psi_pln ---
0.000274912  4.19482e-06  -5.4156e-05           0           0           0
4.19482e-06  2.62571e-05  -9.11603e-06          0           0           0
-5.4156e-05  -9.11603e-06   4.9286e-05           0           0           0
           0           0           0  0.000234439  0.000281423  0.000120601
           0           0           0  0.000281423  0.00568424  0.00411753
           0           0           0  0.000120601  0.00411753  0.00310504

Psi_pln eigen values
(0.00028738,0) (2.19089e-05,0) (4.11654e-05,0) (0.000251945,0) (5.1897e-05,0) (0.00871988,0)
Psi_pln eigen vectors
(-0.974632,0) (0.083846,0) (0.207514,0) (0,0) (0,0) (0,0)
(-0.0234276,0) (0.883863,0) (-0.467158,0) (0,0) (0,0) (0,0)
(0.222583,0) (0.460169,0) (0.859477,0) (0,0) (0,0) (0,0)
(0,0) (0,0) (0,0) (0.926842,0) (-0.373804,0) (-0.035123,0)
(0,0) (0,0) (0,0) (0.195118,0) (0.559482,0) (-0.805549,0)
(0,0) (0,0) (0,0) (-0.320768,0) (-0.739763,0) (-0.591488,0)

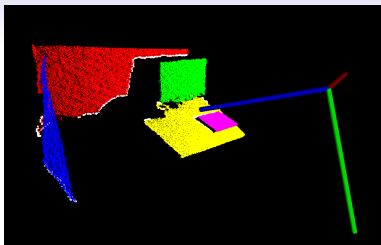
```

(c)

Figure:



(a)



(b)

Psi ---

0.0137979	-0.00354349	0.00296004	0.00480649	0.0225489	-0.00109598
-0.00354349	0.0171298	0.000888859	-0.0200388	-0.00501229	0.00711937
0.00296004	0.000888859	0.00172628	-0.000797285	0.00552693	0.000205801
0.00480649	-0.0200388	-0.000797285	0.0239462	0.00743804	-0.00759343
0.0225489	-0.00501229	0.00552693	0.00743804	0.0380463	-0.00111781
-0.00109598	0.00711937	0.000205801	-0.00759343	-0.00111781	0.00619104

Psi eigen values

(0.0594285,0)	(0.0368413,0)	(0.00339618,0)	(0.00090624,0)	(4.28626e-05,0)	(0.000222388,0)
---------------	---------------	----------------	----------------	-----------------	-----------------

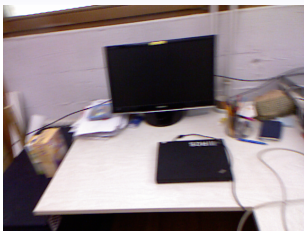
Psi eigen vectors

(0.428033,0)	(-0.267578,0)	(-0.0636188,0)	(-0.43495,0)	(0.446879,0)	(-0.593514,0)
(-0.340582,0)	(-0.525225,0)	(-0.0543098,0)	(0.0614359,0)	(0.641857,0)	(0.435246,0)
(0.077984,0)	(-0.125839,0)	(-0.111252,0)	(0.87845,0)	(0.130252,0)	(-0.420791,0)
(0.424199,0)	(0.59165,0)	(0.299991,0)	(0.147593,0)	(0.522361,0)	(0.292175,0)
(0.70571,0)	(-0.477364,0)	(0.0173331,0)	(0.112946,0)	(-0.303972,0)	(0.410659,0)
(-0.129378,0)	(-0.242443,0)	(0.943574,0)	(0.0287847,0)	(-0.0780596,0)	(-0.165013,0)

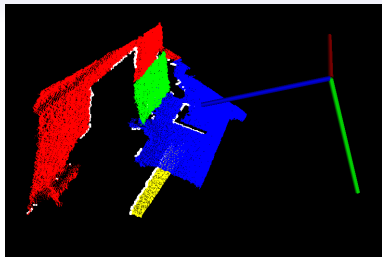
(c)

Figure:

## Shadow point weighting — 5DoF case 1



(a)



(b)

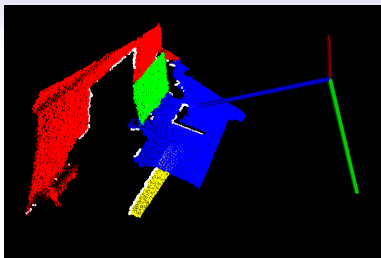
```
H_singularValues ---
  2.37578      1.61775  0.000941738
H_svd_U ---
  0.194237 -0.0457189   0.979889
  0.312307  0.949818  -0.0175907
  0.929912 -0.309443  -0.198768
H_svd_V ---
  0.138932  0.0566767   0.988679
  0.327377  0.939601  -0.0998672
  0.934624 -0.337546  -0.111986
```

(c)

Figure:



(a)



(b)

```

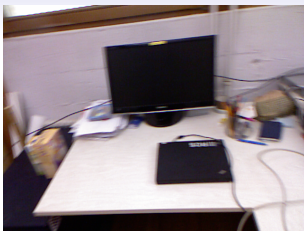
Psi_pln ---
0.000130374  0.00014941  0.000568012      0      0      0
0.00014941  0.00331862  0.000423348      0      0      0
0.000568012 0.000423348  0.00249375      0      0      0
0           0           0      0.0136444  0.00979732  0.00262167
0           0           0      0.00979732  0.00900783  0.00320141
0           0           0      0.00262167  0.00320141  0.00247067
  
```

```

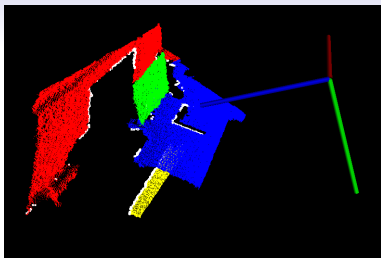
Psi_pln eigen values
(1.23963e-07,0) (0.00353701,0) (0.00240561,0) (0.0222228,0) (0.00233781,0) (0.000562284,0)
Psi_pln eigen vectors
(-0.975483,0) (0.110219,0) (0.190486,0) (0,0) (0,0) (0,0)
(0.0159177,0) (0.898618,0) (-0.438443,0) (0,0) (0,0) (0,0)
(0.219499,0) (0.424662,0) (0.878341,0) (0,0) (0,0) (0,0)
(0,0) (0,0) (0,0) (-0.763035,0) (-0.514966,0) (0.390624,0)
(0,0) (0,0) (0,0) (-0.614358,0) (0.390033,0) (-0.685885,0)
(0,0) (0,0) (0,0) (-0.200851,0) (0.763338,0) (0.613982,0)
  
```

(c)

Figure:



(a)



(b)

Psi ---

0.0447431	0.0113641	-0.0124712	-0.0118991	0.0587335	0.0139788
0.0113641	0.02723	-0.00450331	-0.0332667	0.0162167	0.00755529
-0.0124712	-0.00450331	0.00433665	0.00467976	-0.016542	-0.0043176
-0.0118991	-0.0332667	0.00467976	0.0413332	-0.0169305	-0.00770493
0.0587335	0.0162167	-0.016542	-0.0169305	0.0778689	0.0200323
0.0139788	0.00755529	-0.0043176	-0.00770493	0.0200323	0.0115436

Psi eigen values

(0.143655,0)	(0.0561371,0)	(0.0061903,0)	(0.000162732,0)	(0.000106311,0)	(0.000804225,0)
--------------	---------------	---------------	-----------------	-----------------	-----------------

Psi eigen vectors

(-0.533758,0)	(-0.246827,0)	(0.221144,0)	(-0.601472,0)	(0.480843,0)	(0.110884,0)
(-0.251406,0)	(0.56703,0)	(-0.0208165,0)	(0.446224,0)	(0.620303,0)	(-0.175915,0)
(0.156177,0)	(0.0391338,0)	(-0.0239916,0)	(0.159353,0)	(0.18329,0)	(0.956302,0)
(0.283835,0)	(-0.726093,0)	(-0.125214,0)	(0.349038,0)	(0.475531,0)	(-0.169087,0)
(-0.711871,0)	(-0.29794,0)	(0.0580565,0)	(0.514205,0)	(-0.352421,0)	(0.11177,0)
(-0.200455,0)	(0.00652218,0)	(-0.964903,0)	(-0.165794,0)	(0.00935004,0)	(0.0340979,0)

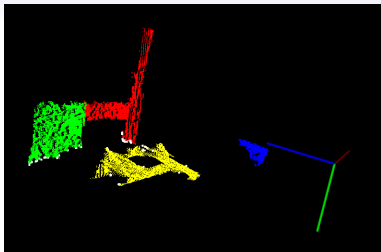
(c)

Figure:

## Shadow point weighting — 5DoF case 2



(a)



(b)

```
H_singularValues ---
  2.00643    0.989269 1.25867e-17
H_svd_U ---
  0.15506 -0.00225214  -0.987902
 -0.0209636  0.999765  -0.00556961
  0.987683  0.0215736   0.154976
H_svd_V ---
  0.1726  0.0173261    0.98484
  0.0229112  0.999504  -0.0215994
  0.984725 -0.0262919  -0.172118
```

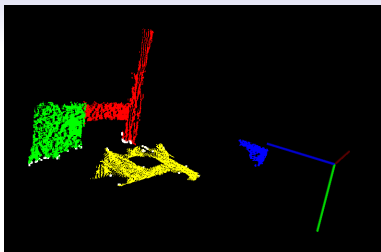
(c)

Figure:





(a)



(b)

```

Psi_pln ---
  0.00050064 -0.000274369  0.00277648      0      0      0
-0.000274369  0.000693042 -0.00155663      0      0      0
  0.00277648 -0.00155663  0.0178549      0      0      0
           0           0           0      0.0074052  0.00152952  0.00043059
           0           0           0      0.00152952  0.00777214 -2.76184e-06
           0           0           0      0.00043059 -2.76184e-06  0.000541582
  
```

Psi\_pln eigen values

(6.52996e-05,0) (0.0184291,0) (0.000554193,0) (0.00913855,0) (0.00606709,0) (0.000513283,0)

Psi\_pln eigen vectors

```

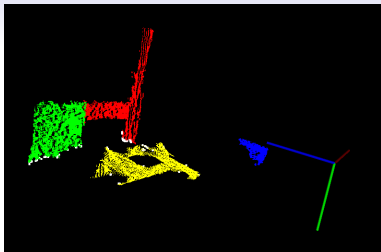
(0.986897,0) (0.153762,0) (-0.0489056,0) (0,0) (0,0) (0,0)
(0.0630879,0) (-0.0887506,0) (0.994054,0) (0,0) (0,0) (0,0)
(-0.148507,0) (0.984114,0) (0.0972882,0) (0,0) (0,0) (0,0)
(0,0) (0,0) (0,0) (-0.665892,0) (-0.743168,0) (-0.0654836,0)
(0,0) (0,0) (0,0) (-0.745313,0) (0.666564,0) (0.0141777,0)
(0,0) (0,0) (0,0) (-0.0331126,0) (-0.0582466,0) (0.997753,0)
  
```

(c)

Figure:



(a)



(b)

Psi ---

0.388766	1.48713	-0.143367	-4.15424	0.972701	-1.39746
1.48713	8.26728	-1.1456	-23.2028	3.38047	-6.62527
-0.143367	-1.1456	0.202294	3.1708	-0.261244	0.773766
-4.15424	-23.2028	3.1708	65.6051	-9.50493	18.9005
0.972701	3.38047	-0.261244	-9.50493	2.54666	-3.23372
-1.39746	-6.62527	0.773766	18.9005	-3.23372	6.60999

Psi eigen values

(81.1896,0)	(1.67105,0)	(0.693812,0)	(0.061955,0)	(0.000523253,0)	(0.00311623,0)
-------------	-------------	--------------	--------------	-----------------	----------------

Psi eigen vectors

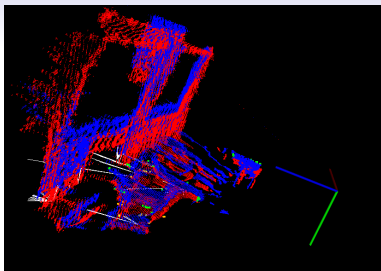
(-0.058263,0)	(-0.233187,0)	(0.155944,0)	(-0.254643,0)	(-0.694797,0)	(0.608543,0)
(-0.317747,0)	(0.105244,0)	(0.12133,0)	(-0.811137,0)	(-0.0838685,0)	(-0.456359,0)
(0.0427073,0)	(-0.159235,0)	(0.0347741,0)	(0.392083,0)	(-0.643018,0)	(-0.635932,0)
(0.898126,0)	(-0.249635,0)	(-0.0754284,0)	(-0.336415,0)	(0.0196923,0)	(-0.108629,0)
(-0.133892,0)	(-0.70048,0)	(0.624908,0)	(0.0621062,0)	(0.303897,0)	(-0.0684145,0)
(0.263177,0)	(0.596827,0)	(0.750701,0)	(0.0803317,0)	(-0.0633232,0)	(0.0228379,0)

(c)

Figure:



(a)



(b)

```

matched plane --- 0 --- <1,3>
0.811612   4.23148  -0.575928  -11.9343   1.79257  -3.74018
4.23148   24.4606  -3.49168  -68.7273   9.45296  -19.4241
-0.575928 -3.49168  0.535635   9.61613  -1.25927  2.48136
-11.9343  -68.7273   9.61613  194.515  -26.9563   55.587
1.79257   9.45296  -1.25927  -26.9563  4.05186  -8.29663
-3.74018  -19.4241  2.48136   55.587  -8.29663  19.0698

eigen values
(239.868,0)   (3.16209,0)   (0.233599,0)   (0.177861,0) (0.000879034,0) (0.00170361,0)
eigen vectors
(-0.0556884,0) (-0.0921312,0) (-0.248291,0) (-0.380783,0) (0.874526,0) (-0.130273,0)
(-0.317996,0) (0.163024,0) (0.319573,0) (-0.736566,0) (-0.289547,0) (-0.37922,0)
(0.0442998,0) (-0.101481,0) (-0.181885,0) (0.361196,0) (-0.0373621,0) (-0.907082,0)
(0.900054,0) (-0.236866,0) (0.0565628,0) (-0.337242,0) (-0.108951,0) (-0.070686,0)
(-0.125466,0) (-0.169156,0) (-0.861042,0) (-0.261292,0) (-0.369649,0) (0.096631,0)
(0.260723,0) (0.932694,0) (-0.24197,0) (-0.00260475,0) (0.0382201,0) (-0.0457057,0)

```

(c)

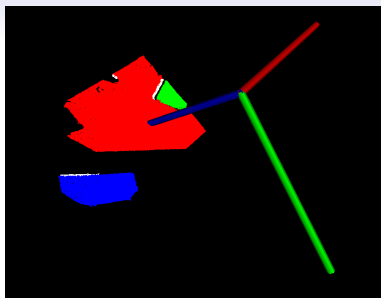
Figure:



## Shadow point weighting — 3DoF case



(a)



(b)

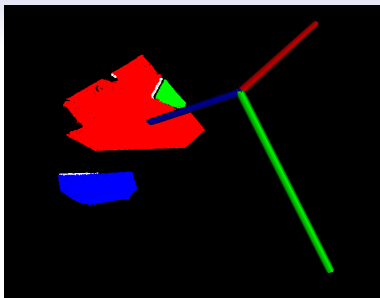
```
H_singularValues ---
  2.99697  0.00231376  0.000691409
H_svd_U ---
-0.00149617  0.403484  0.914986
  0.54815  0.765607  -0.336715
  0.836378  -0.501046  0.222315
H_svd_V ---
-0.00891602  0.326818  0.945045
  0.554482  0.788096  -0.26731
  0.832148  -0.521627  0.188242
```

(c)

Figure:



(a)



(b)

Psi\_pln ---

1.63154e-10	-1.22542e-08	-1.99978e-08	0	0	0
-1.22542e-08	1.06594e-06	1.74992e-06	0	0	0
-1.99978e-08	1.74992e-06	2.87341e-06	0	0	0
0	0	0	0.000127403	0.000103164	-6.57474e-05
0	0	0	0.000103164	0.000115035	-7.37753e-05
0	0	0	-6.57474e-05	-7.37753e-05	4.73192e-05

Psi\_pln eigen values

(-3.45176e-23,0) (3.93932e-06,0) (1.96726e-10,0) (0.000268452,0) (2.13059e-05,0) (2.98449e-21,0)

Psi\_pln eigen vectors

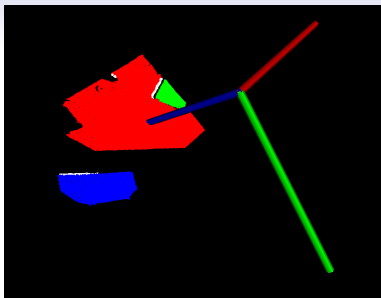
(-0.938324,0)	(-0.00595386,0)	(0.345705,0)	(0,0)	(0,0)	(0,0)
(-0.298167,0)	(0.520153,0)	(-0.800336,0)	(0,0)	(0,0)	(0,0)
(0.175054,0)	(0.854053,0)	(0.489847,0)	(0,0)	(0,0)	(0,0)
(0,0)	(0,0)	(0,0)	(0.65521,0)	(0.755381,0)	(-0.00994885,0)
(0,0)	(0,0)	(0,0)	(0.636363,0)	(-0.544782,0)	(0.546127,0)
(0,0)	(0,0)	(0,0)	(-0.407114,0)	(0.364159,0)	(0.837643,0)

(c)

Figure:



(a)



(b)

```

Psi ---
 0.00573844    0.0061686    0.00162286   -0.00352708    0.00392638   -0.00146068
 0.0061686    0.0308165   -0.000201337   -0.0183101    0.00341866   -0.00783722
 0.00162286  -0.000201337    0.000728696    0.000143911    0.00118851    0.000108412
 -0.00352708  -0.0183101    0.000143911    0.0108911    -0.00193358    0.00465353
 0.00392638    0.00341866    0.00118851   -0.00193358    0.00272364   -0.000794255
 -0.00146068  -0.00783722    0.000108412    0.00465353   -0.000794255    0.00203388

Psi eigen values
(0.0455408,0) (0.00724054,0) (0.000111333,0) (5.55555e-06,0) (3.33931e-05,0) (6.50427e-07,0)
Psi eigen vectors
(0.188734,0) (0.753038,0) (0.268555,0) (0.552414,0) (0.141,0) (-0.0122364,0)
(0.820064,0) (-0.161551,0) (0.015187,0) (-0.0968354,0) (0.160328,0) (0.515832,0)
(0.00396817,0) (0.296457,0) (-0.89757,0) (0.0955942,0) (-0.235847,0) (0.204213,0)
(-0.486559,0) (0.118916,0) (0.242963,0) (-0.0701674,0) (-0.100367,0) (0.821639,0)
(0.108726,0) (0.548751,0) (0.0939189,0) (-0.807886,0) (-0.100741,0) (-0.124107,0)
(-0.208078,0) (0.06066,0) (-0.232731,0) (-0.136826,0) (0.93732,0) (0.0396329,0)

```

(c)

Figure:



# Plane fusion

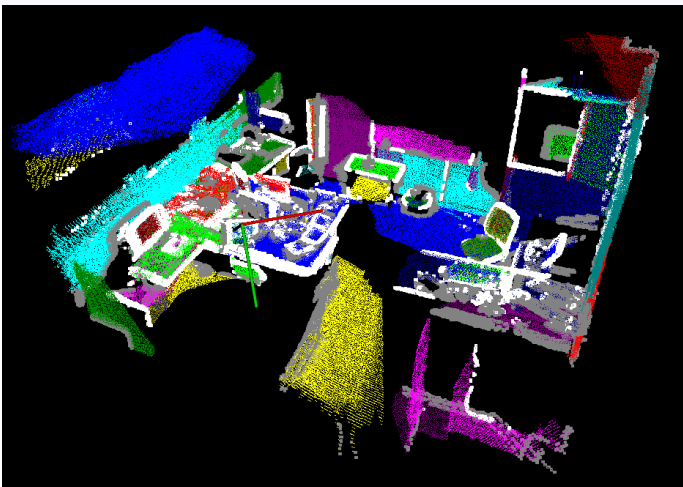


Figure: 249 frames, 64 planes.

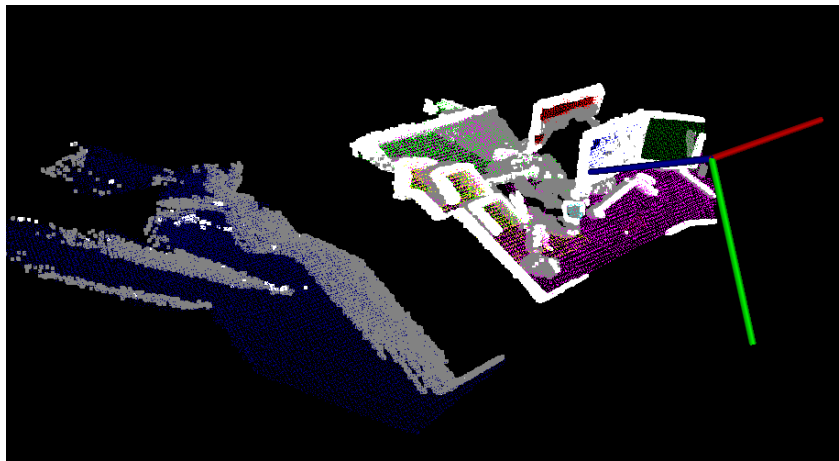


Figure: 60 frames, 8 planes.

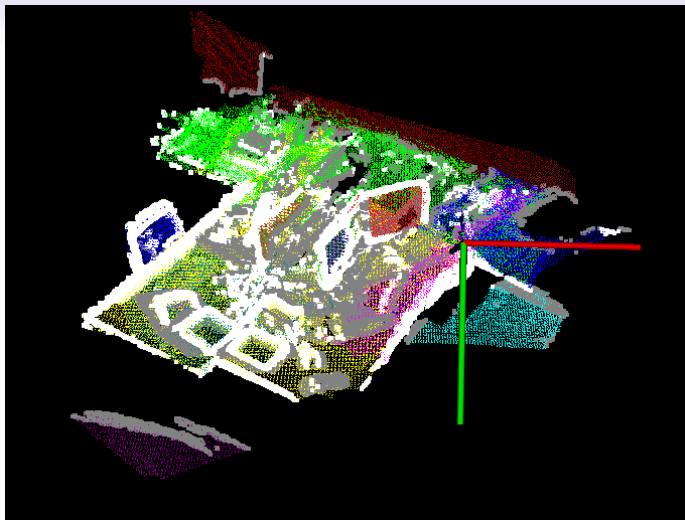


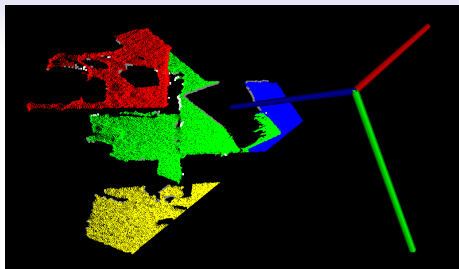
Figure: 130 frames, 23 planes.

Figure:

## Problems with plane segmentation



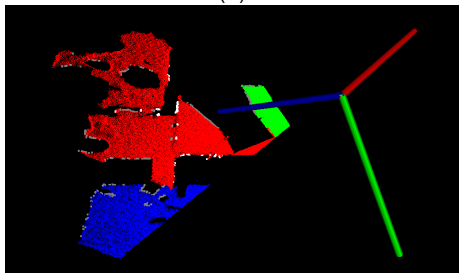
(a)



(b)

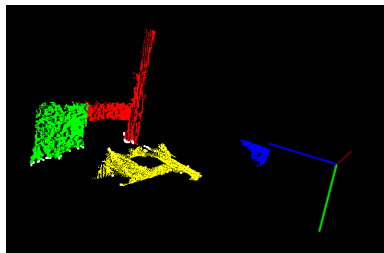


(c)

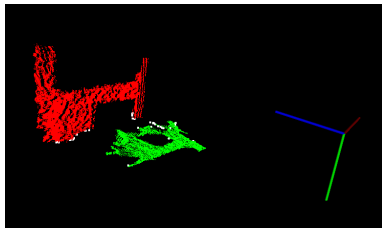


(d)

Figure:



(a)



(b)

Figure: