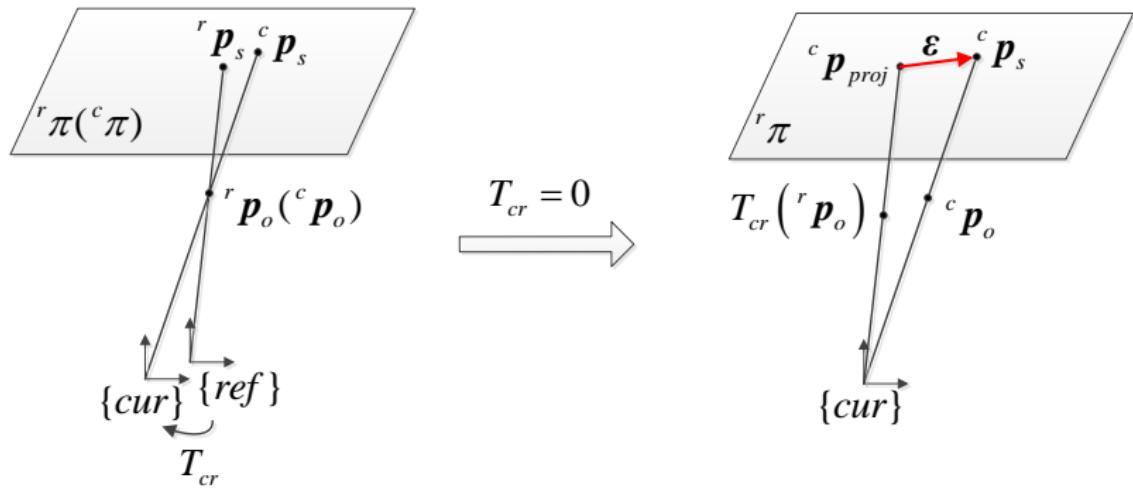


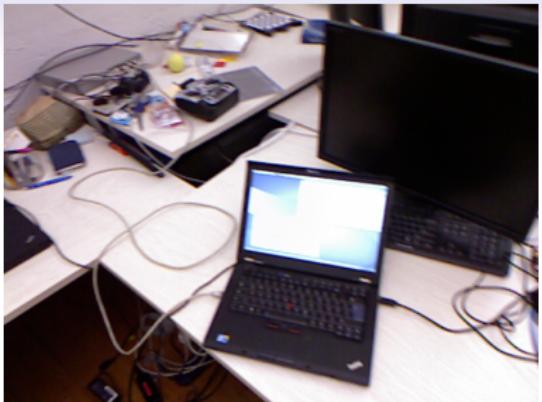
# Plane Feature and Projective Shadow based SLAM

Sun Qinxuan

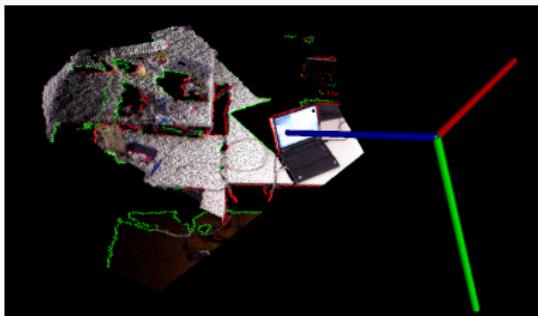
June 30, 2017



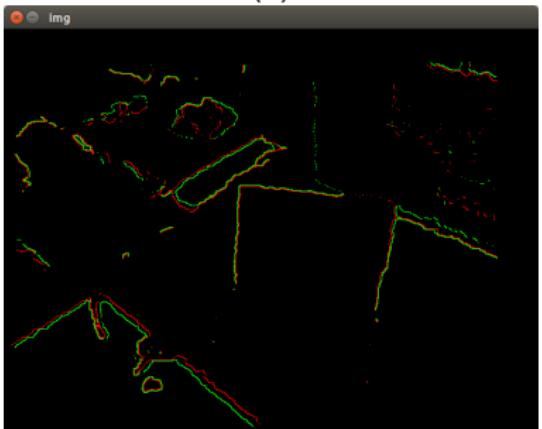
## Shadow point extraction



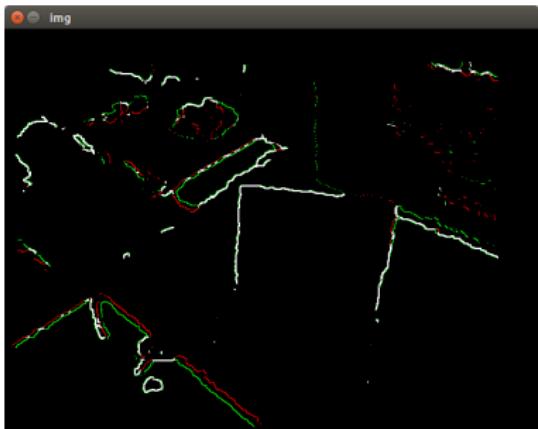
(a)



(b)



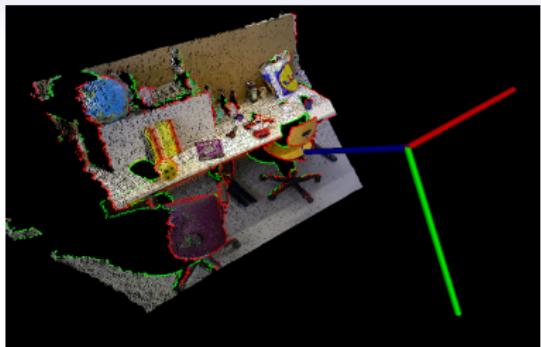
(c)



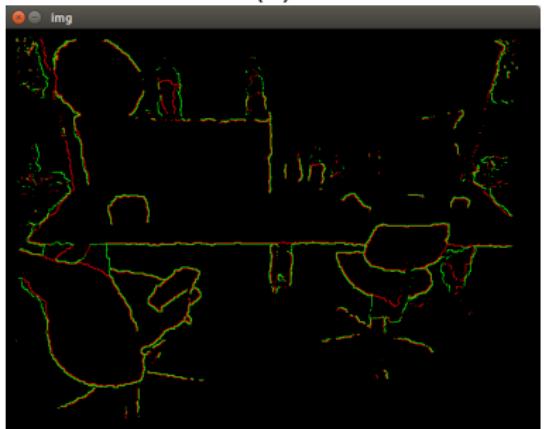
(d)



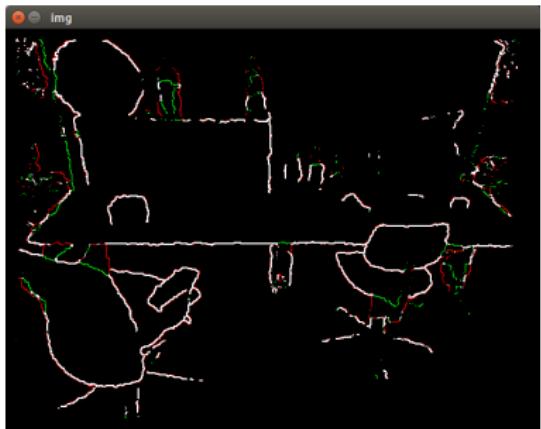
(a)



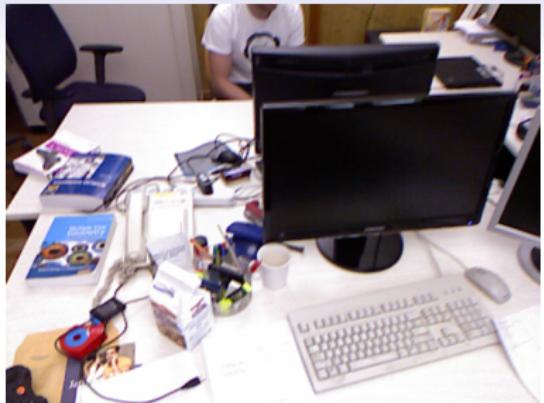
(b)



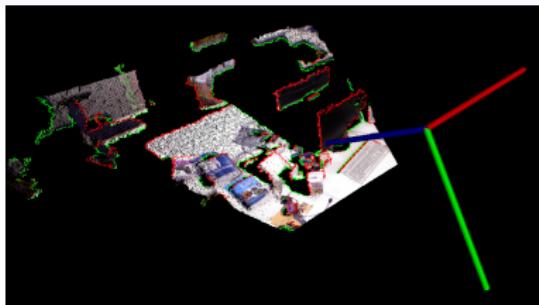
(c)



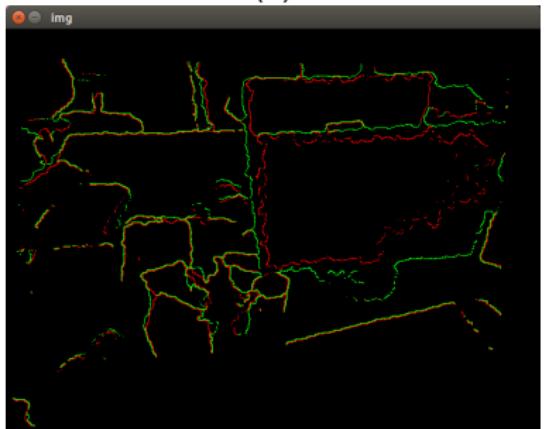
(d)



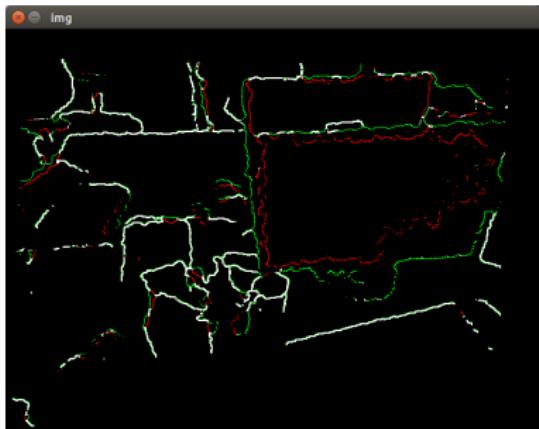
(a)



(b)

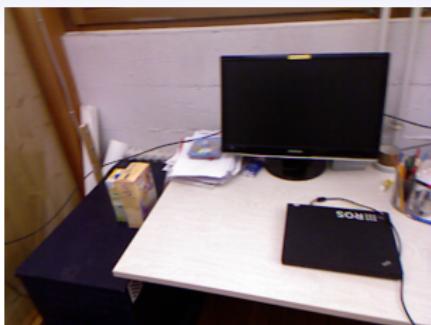


(c)

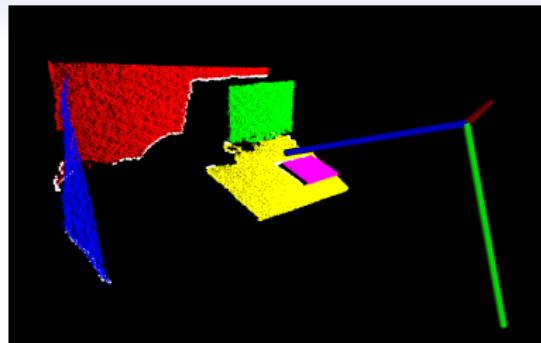


(d)

## **Shadow point weighting — 6DoF case**



(a)

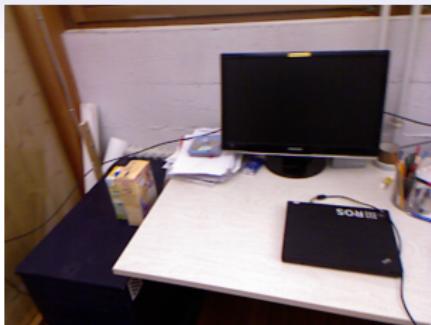


(b)

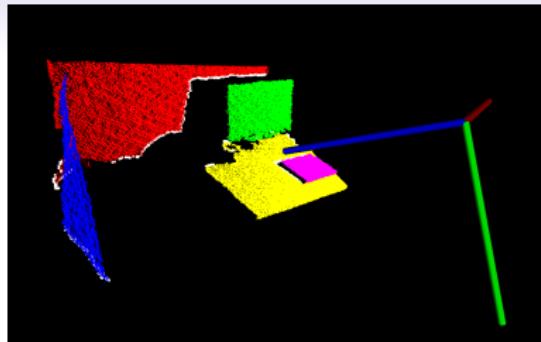
```
H_singularValues ---  
2.34828 1.65432 0.99723  
H_svd_U ---  
0.196086 -0.18783 0.962429  
0.309457 0.943181 0.121024  
0.930477 -0.274099 -0.24307  
H_svd_V ---  
0.231686 -0.240971 0.942473  
0.322836 0.932973 0.15918  
0.917659 -0.267385 -0.293951
```

(c)

Figure:



(a)

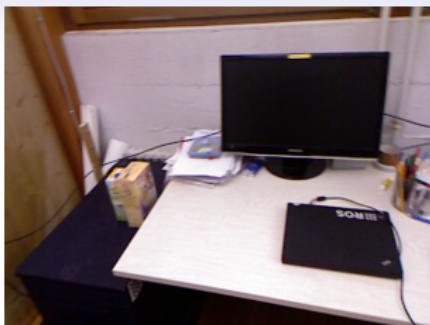


(b)

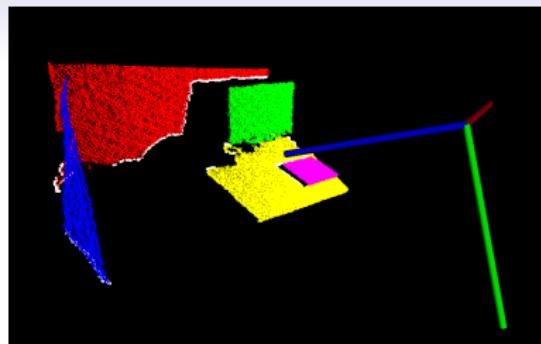
```
Psi_pln ---  
0.000274912 4.19482e-06 -5.4156e-05      0          0          0  
4.19482e-06 2.62571e-05 -9.11603e-06      0          0          0  
-5.4156e-05 -9.11603e-06 4.9286e-05      0          0          0  
    0          0          0  0.000234439  0.000281423  0.000120601  
    0          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)

```

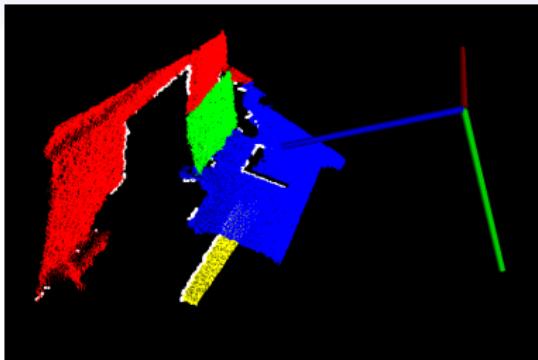
(c)

Figure:

## **Shadow point weighting — 5DoF case 1**



(a)

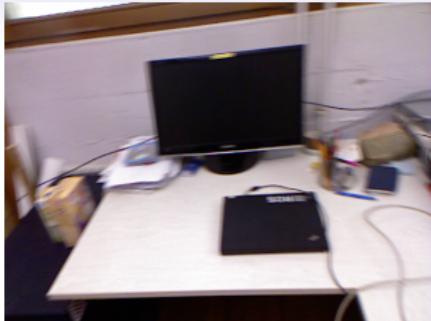


(b)

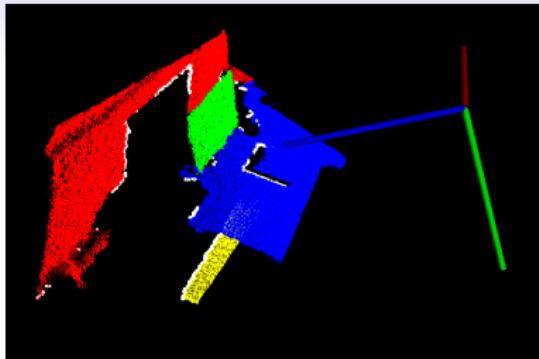
```
H_singularValues ---  
    2.37578      1.61775  0.000941738  
H_svd_U ---  
  0.194237 -0.0457189   0.979889  
  0.312307   0.949818 -0.0175907  
  0.929912 -0.309443  -0.198768  
H_svd_V ---  
  0.138932  0.0566767   0.988679  
  0.327377   0.939601 -0.0998672  
  0.934624 -0.337546  -0.111986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

(c)

Figure:



(a)

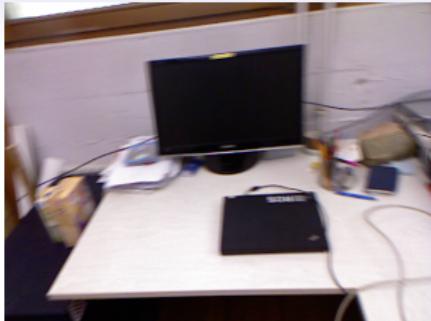


(b)

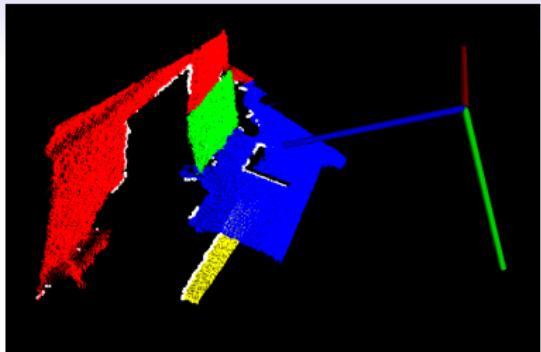
```
Psi_pln ---  
0.000130374  0.00014941  0.000568012      0          0          0  
0.00014941  0.00331862  0.000423348      0          0          0  
0.000568012  0.000423348  0.00249375     0          0          0  
    0          0          0  0.0136444  0.00979732  0.00262167  
    0          0          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)
```

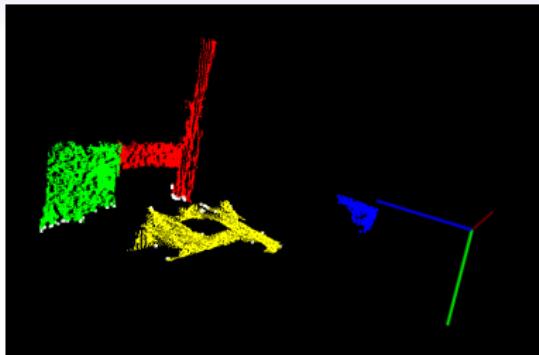
(c)

Figure:

## Shadow point weighting — 5DoF case 2



(a)



(b)

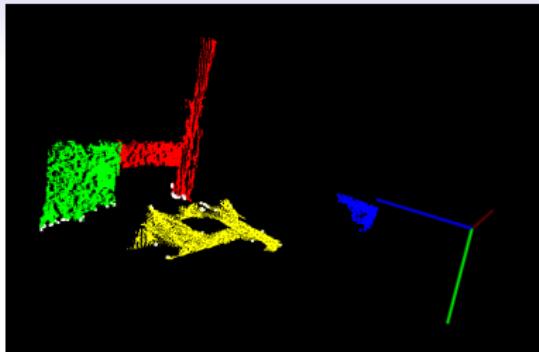
```
H_singularValues ---
  2.00643   0.989269  1.25867e-17
H_svd_U ---
  0.15506 -0.00225214  -0.987902
 -0.0209636   0.999765 -0.00556961
  0.987683   0.0215736   0.154976
H_svd_V ---
  0.1726   0.0173261    0.98484
  0.0229112   0.999504 -0.0215994
  0.984725 -0.0262919  -0.172118
```

(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)
```

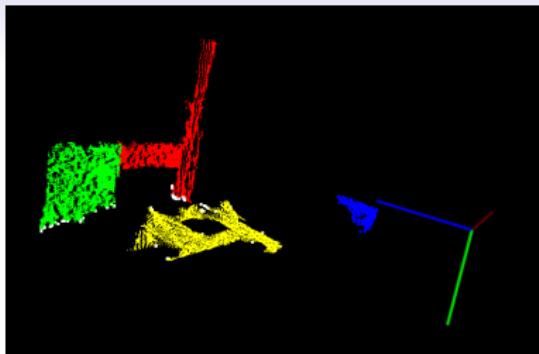
```
Psi_pln eigen vectors  
(0.986897,0)  (0.153762,0) (-0.0489056,0)      (0,0)      (0,0)      (0,0)  
(0.0630879,0) (-0.0887506,0)  (0.994654,0)      (0,0)      (0,0)      (0,0)  
(-0.148507,0)  (0.984114,0)  (0.0972882,0)      (0,0)      (0,0)      (0,0)  
(0,0)          (0,0)          (0,0)  (-0.665892,0)  (-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)

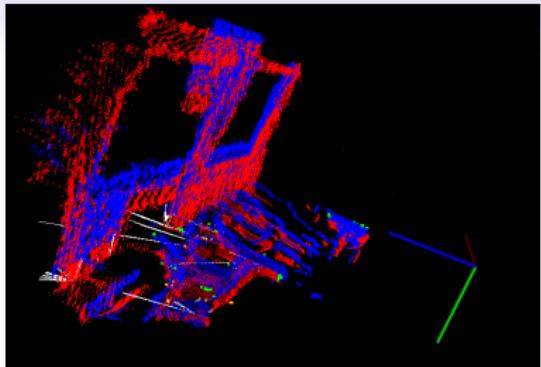
```
Psi ---  
 0.388766  1.48713 -0.143367 -4.15424  0.972701 -1.39746  
 1.48713   8.26728 -1.1456 -23.2028  3.38047 -6.62527  
-0.143367 -1.1456  0.202294  3.1708 -0.261244  0.773766  
-4.15424  -23.2028  3.1708  65.6051 -9.50493  18.9005  
 0.972701   3.38047 -0.261244 -9.50493  2.54666 -3.23372 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

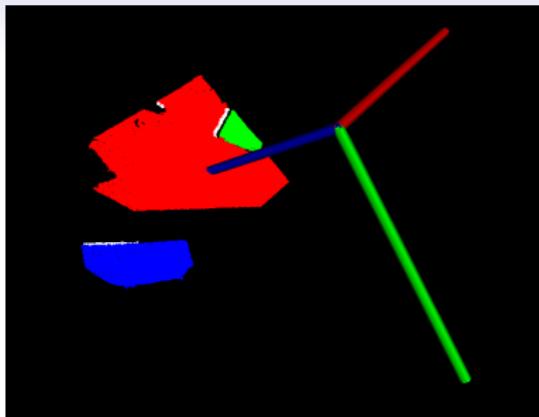
Figure:



## **Shadow point weighting — 3DoF case**



(a)

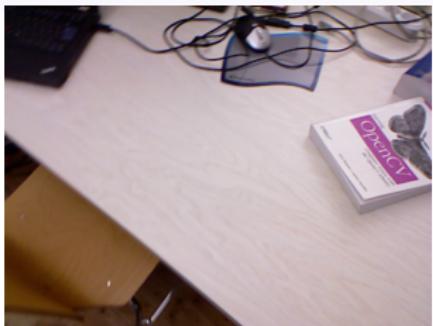


(b)

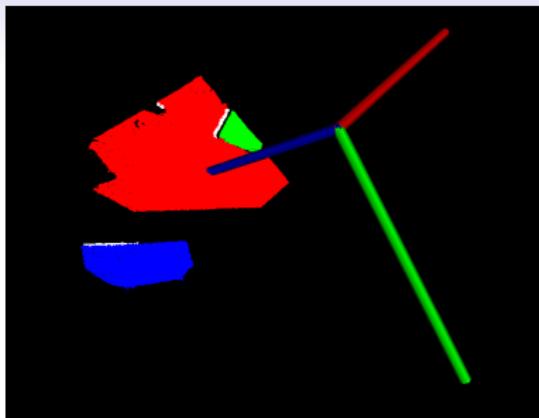
```
H_singularValues ---  
    2.99697  0.00231376  0.000691409  
H_svd_U ---  
-0.00149617   0.403484   0.914986  
    0.54815   0.765607  -0.336715  
    0.836378  -0.501046   0.222315  
H_svd_V ---  
-0.00891602   0.326818   0.945045  
    0.554482   0.788096  -0.26731  
    0.832148  -0.521627  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

(c)

Figure:



(a)



(b)

```

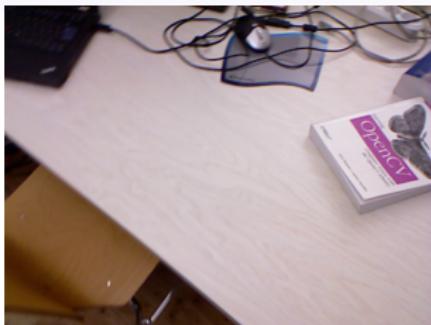
Psi_pln ---
 1.63154e-10 -1.22542e-08 -1.99978e-08          0          0          0
-1.22542e-08  1.06594e-06  1.74992e-06          0          0          0
-1.99978e-08  1.74992e-06  2.87341e-06          0          0          0
          0          0          0  0.000127403  0.000103164 -6.57474e-05
          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)

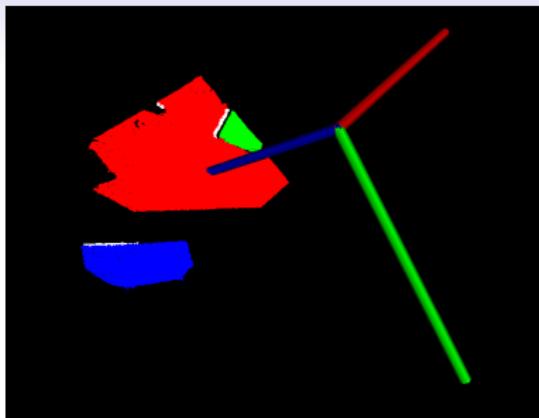
```

(c)

Figure:



(a)



(b)

Psi ---

```
 0.00573844   0.0061686   0.00162286  -0.000352708   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

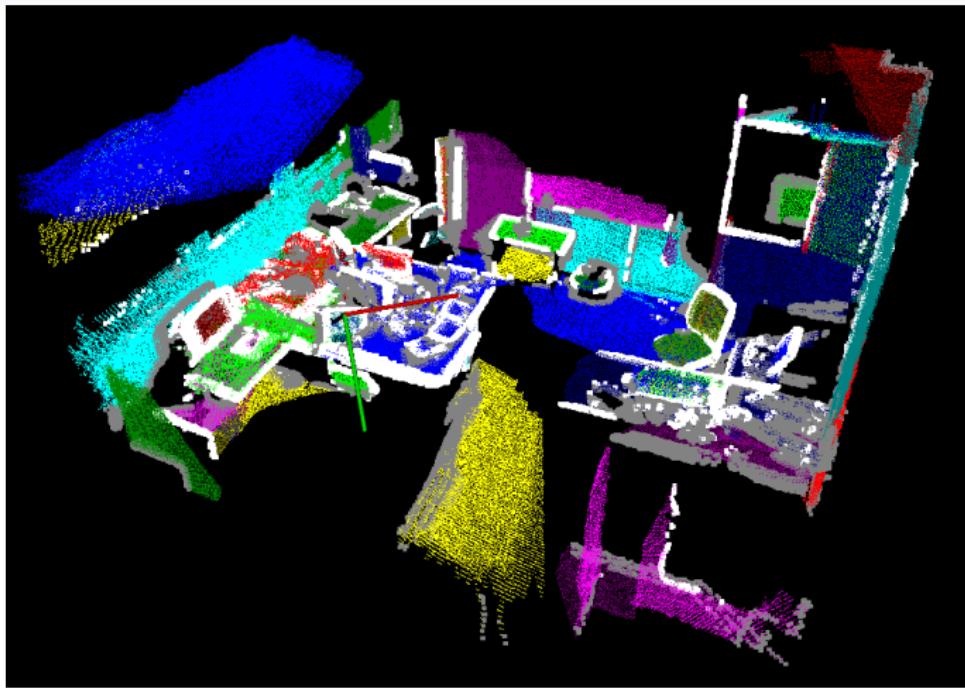


Figure: 249 frames, 64 planes.

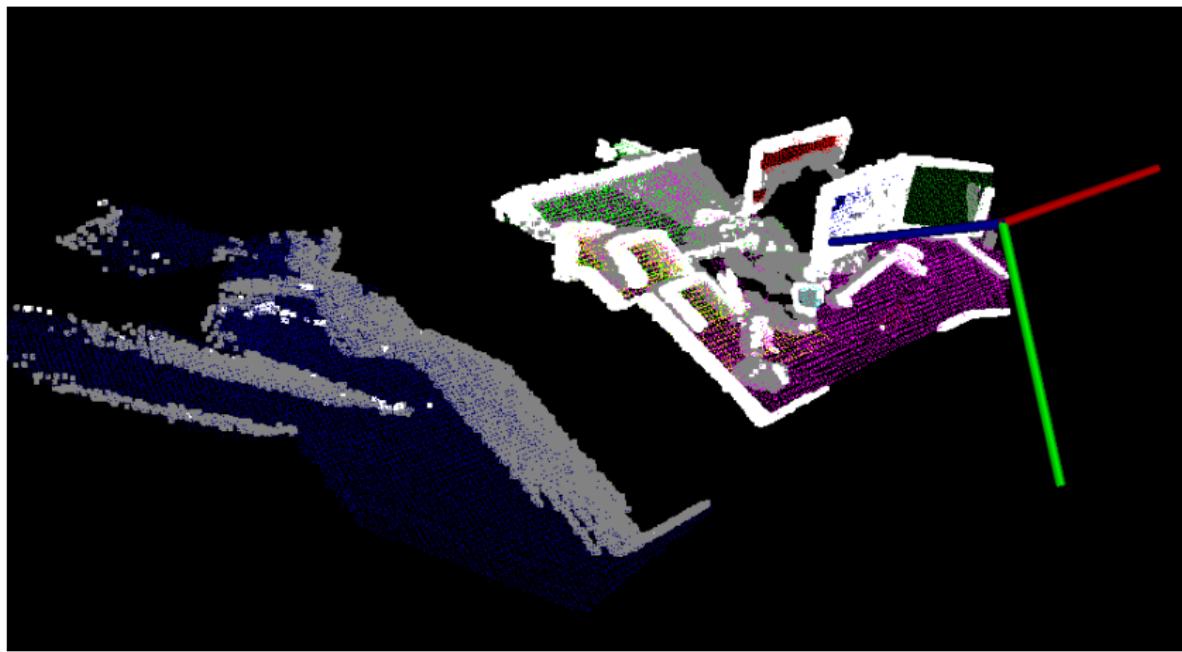


Figure: 60 frames, 8 planes.

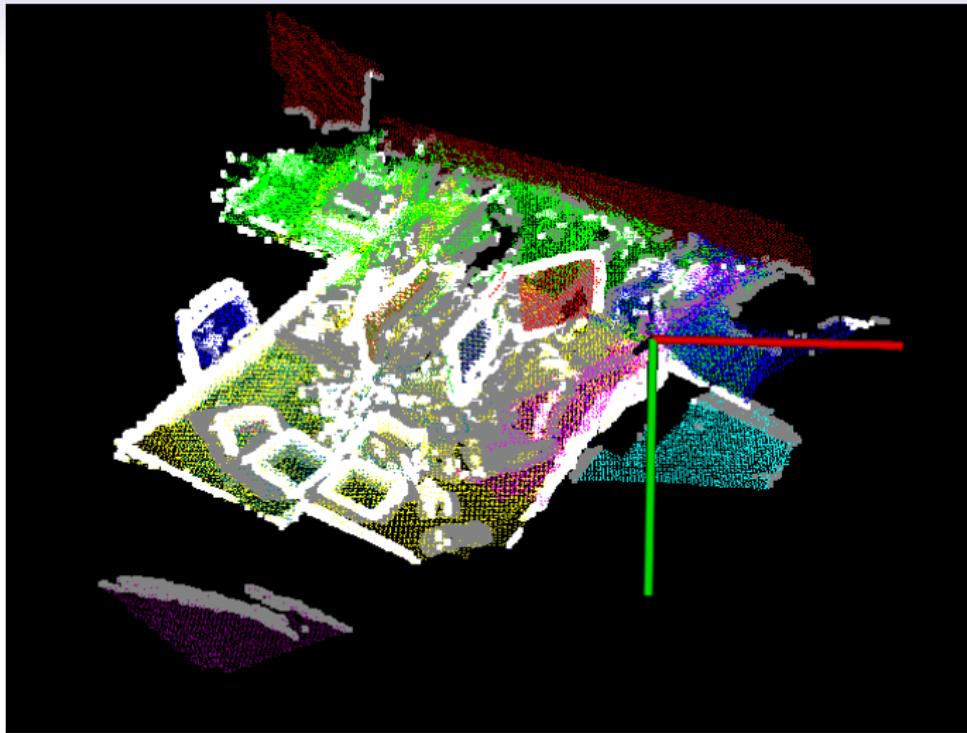


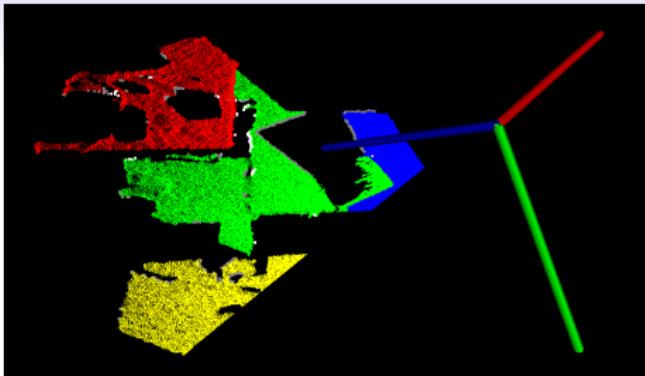
Figure: 130 frames, 23 planes.

Figure:

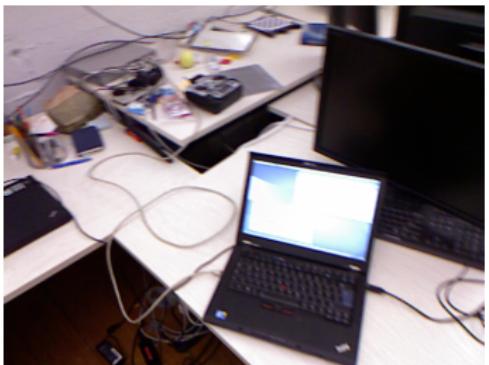
## Problems with plane segmentation



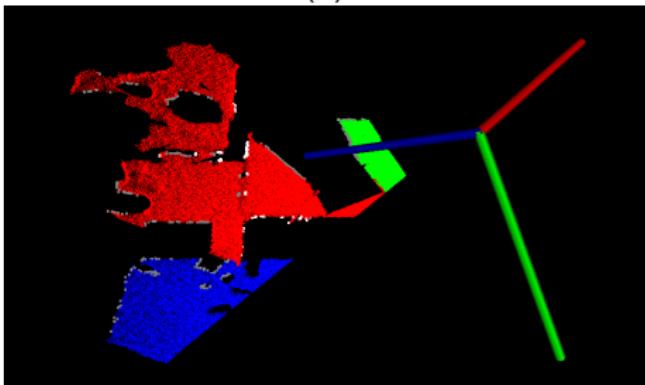
(a)



(b)

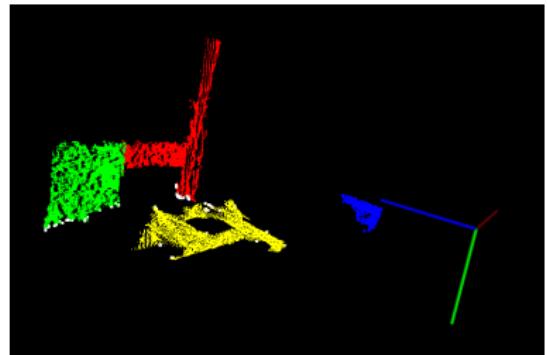


(c)

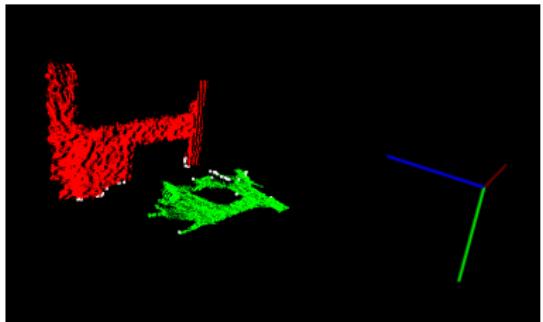


(d)

Figure:



(a)



(b)

Figure: