

Extrinsic Calibration Report

1. Simulation info

- vrep simulation sence
- pose num: 100
- camera intrinsic parameters:
 - "fx":1.097987543300894e+03
 - "fy":1.097987543300894e+03
 - "cx":512
 - "cy":512
- ground truth:
 - q = [-3.693209215998650e-02, -4.218471050262451e-01, 7.866000384092331e-02, -9.024930000305176e-01]
 - t = [4.224271774291992e-01, 6.744502782821655e-01, -4.615702629089355e-01]

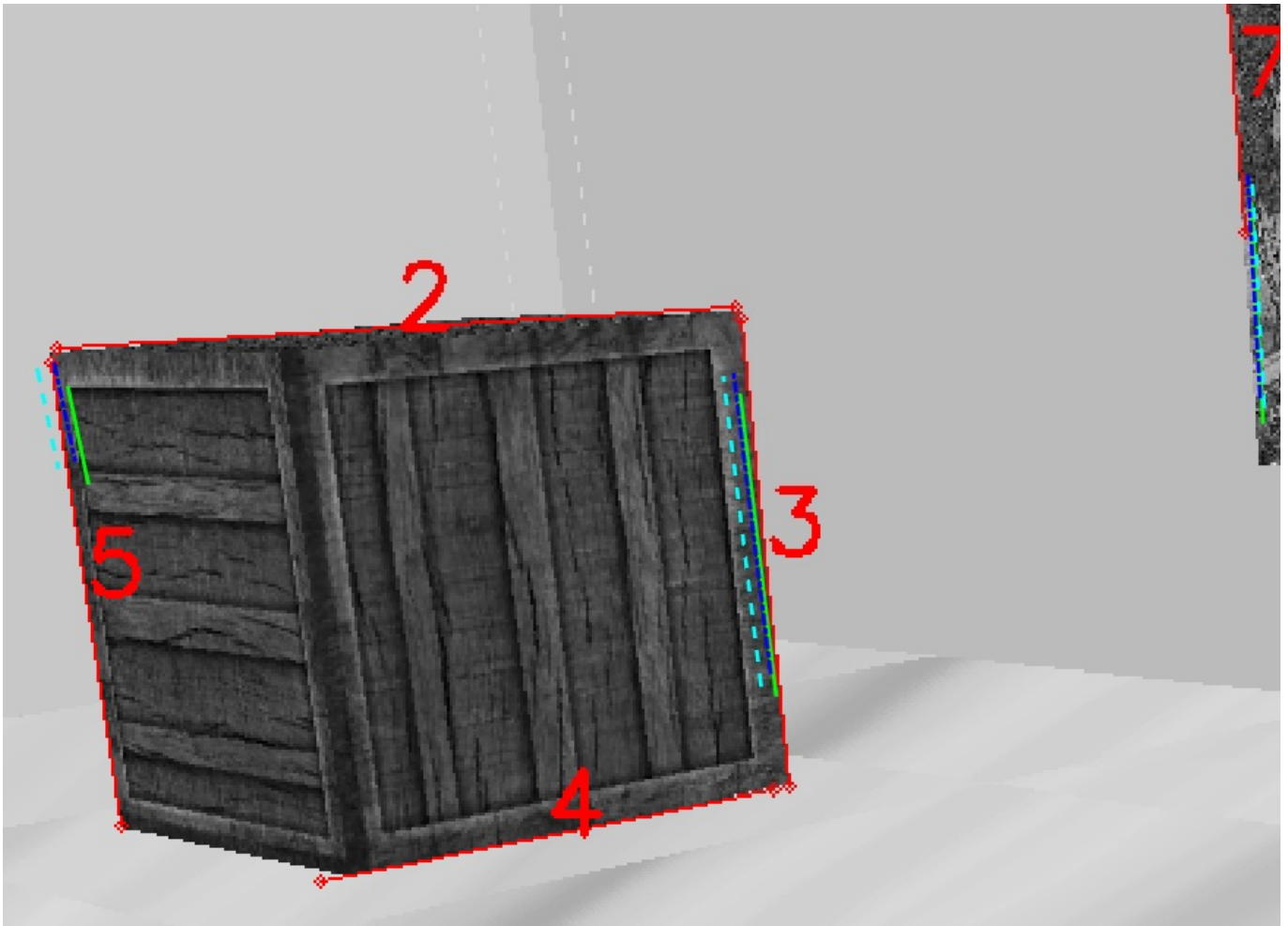
2. Experiment Results

Transformation Error

item	value	absolute error	relative error
q_initial	[0.0383855904508847, 0.428071227889441, -0.0798624312365283, 0.899390661712670]	-	0.0046
q_optimized	[0.0363163377020377, 0.420256088440555, -0.0811983273601663, 0.903035312365174]	-	0.0020
t_inital	[0.523498000000000, 0.658330000000000, -0.232022000000000]	0.2513 m	0.2732
t_optimized	[0.484223365904858, 0.639227925263736, -0.446568222161614]	0.0727m	0.0790

Transformation Effect

3D lines reprojected to image



green: with ground truth transformation, cyan: initial parameters, blue: optimized parameters

3. Experiment Logs

initial step

```
config path: ../config/config.json  
file base path: ../../data/0214/  
record num: 100
```

-----start-----

```
add: 0  
No pose in list
```

```
add: 1  
Start #1 thread(s)  
Fail: angle_err: 2.82658  
0 : 1  
Pair size: 0  
1 no enough pairs
```

```
add: 2  
Start #2 thread(s)  
Fail: angle_err: 3.37329  
0 : 2  
Pair size: 1  
2 no enough pairs
```

```
add: 3  
Start #3 thread(s)  
Fail: angle_err: 0.582191  
2 : 3  
Fail: angle_err: 1.41609
```

```

1 : 3
Fail: angle_err: 7.2147
0 : 3
Pair size: 1
3 no enough pairs

add: 4
Start #4 thread(s)
Fail: angle_err: 1.27057
3 : 4
Fail: angle_err: 0.961435
2 : 4
Fail: angle_err: 1.26177
1 : 4
Fail: angle_err: 2.28723
0 : 4
Pair size: 1
4 no enough pairs

add: 5
Start #4 thread(s)
Pair size: 5
5 no enough pairs

add: 6
Start #4 thread(s)
Fail: angle_err: 1.3415
5 : 6
Pair size: 6
6 no enough pairs

add: 7
Start #4 thread(s)
Fail: angle_err: 1.6598
5 : 7
Pair size: 7
7 no enough pairs

add: 8
Start #4 thread(s)
Fail: angle_err: 2.12051
6 : 8
Pair size: 8
q vector: 0.0106564
  0.376175
-0.0732999
  0.923583
matrix T:
-0.716757 -0.0748314  0.693296  0.468236
-0.0354631 -0.989027 -0.143414  0.0198995
  0.69642  -0.12738  0.706239 -0.780006
      0      0      0      1

add: 9
Start #4 thread(s)
Fail: angle_err: 1.3977
6 : 9
Pair size: 10
q vector: 0.0119918
  0.380667
-0.0751446
  0.921576
matrix T:
-0.709898 -0.0793129  0.699825  0.469254
-0.0351074 -0.988419 -0.147633  0.0252084
  0.703429 -0.129373  0.698892 -0.771357
      0      0      0      1

```

```
add: 10
Start #4 thread(s)
Fail: angle_err: 1.52241
7 : 10
Fail: angle_err: 2.36252
6 : 10
Pair size: 12
q vector: 0.0135383
  0.383803
-0.0766971
  0.920125
matrix T:
-0.705024 -0.083787  0.704217  0.39843
-0.0339594 -0.987869 -0.151534 -0.23549
  0.70837 -0.13075  0.693626 -0.721298
      0      0      0      1
```

```
add: 11
Start #4 thread(s)
Fail: angle_err: 0.70498
10 : 11
Fail: angle_err: 0.617597
9 : 11
Fail: angle_err: 0.502559
8 : 11
Fail: angle_err: 2.43771
6 : 11
Pair size: 13
q vector: 0.0161703
  0.391991
-0.0799991
  0.916341
matrix T:
-0.692163 -0.0923529  0.715808  0.509246
-0.0330828 -0.986677 -0.15929  0.220642
  0.720983 -0.133936  0.679886 -0.754467
      0      0      0      1
```

```
add: 12
Start #4 thread(s)
Fail: angle_err: 1.37567
10 : 12
Fail: angle_err: 0.739219
9 : 12
Pair size: 16
q vector: 0.018306
  0.399656
-0.082508
  0.912761
matrix T:
-0.67988 -0.0993676  0.72656  0.559386
-0.0325317 -0.985715 -0.165252  0.438767
  0.732601 -0.135988  0.666935 -0.774029
      0      0      0      1
```

```
add: 13
Start #4 thread(s)
Fail: angle_err: 2.1334
12 : 13
Fail: angle_err: 2.55383
10 : 13
Fail: angle_err: 3.47879
9 : 13
Pair size: 18
q vector: 0.0173099
  0.385876
-0.0797294
  0.918936
```

```
matrix T:
-0.701601 -0.0933447 0.70643 0.580946
-0.0297178 -0.986687 -0.159891 0.57519
0.71195 -0.133173 0.689486 -0.83324
0 0 0 1
```

add: 14

```
Start #4 thread(s)
Fail: angle_err: 1.01684
10 : 14
Fail: angle_err: 2.05458
9 : 14
```

Pair **size:** 21

```
q vector: 0.018067
0.387778
-0.0795998
0.918132
```

```
matrix T:
-0.698604 -0.0949097 0.709186 0.582295
-0.0285583 -0.986675 -0.160178 0.558367
0.714938 -0.132154 0.686585 -0.814541
0 0 0 1
```

add: 15

```
Start #4 thread(s)
Fail: angle_err: 2.41806
10 : 15
Pair size: 25
```

```
q vector: 0.0195853
0.391651
-0.0796772
0.916448
```

```
matrix T:
-0.692451 -0.0983093 0.714735 0.58726
-0.0265135 -0.986536 -0.161381 0.524145
0.720977 -0.130699 0.680521 -0.792576
0 0 0 1
```

add: 16

```
Start #4 thread(s)
Pair size: 30
```

```
q vector: 0.0215239
0.396964
-0.0797628
0.914108
```

```
matrix T:
-0.683912 -0.102676 0.722303 0.59136
-0.0239757 -0.986349 -0.162912 0.539195
0.729171 -0.128735 0.672114 -0.776949
0 0 0 1
```

add: 17

```
Start #4 thread(s)
Pair size: 35
```

```
q vector:0.0220115
0.398226
-0.079676
0.913555
```

```
matrix T:
-0.681863 -0.103675 0.724095 0.597013
-0.0232407 -0.986334 -0.163108 0.465643
0.73111 -0.128046 0.670136 -0.764256
0 0 0 1
```

add: 18

```
Start #4 thread(s)
Pair size: 40
```

```
q vector:0.0237059
```

```
0.401778
-0.079669
0.911957
matrix T:
-0.676026 -0.107256 0.729031 0.594042
-0.0207808 -0.986182 -0.164358 0.502345
0.736585 -0.12626 0.664455 -0.7487
0 0 0 1
```

add: 19

Start #4 thread(s)

Pair **size:** 45

q vector: 0.0257161

0.40551

-0.079875

0.910231

matrix T:

-0.669801 -0.111595 0.734107 0.587371

-0.017965 -0.985917 -0.166266 0.582583

0.742324 -0.124553 0.658363 -0.736798

0 0 0 1

add: 20

Start #4 thread(s)

Fail: angle_err: 0.880799

19 : 20

Fail: angle_err: 1.15012

18 : 20

Pair **size:** 48

q vector: 0.0273001

0.408677

-0.0800736

0.90875

matrix T:

-0.664475 -0.115066 0.738399 0.573564

-0.0158306 -0.985686 -0.167847 0.657516

0.747143 -0.12322 0.653142 -0.717233

0 0 0 1

add: 21

Start #4 thread(s)

Fail: angle_err: 1.57738

19 : 21

Pair **size:** 52

q vector: 0.0284601

0.411297

-0.0799864

0.907539

matrix T:

-0.660049 -0.117454 0.741984 0.569619

-0.0141392 -0.985584 -0.168593 0.657566

0.75109 -0.12177 0.648873 -0.691207

0 0 0 1

add: 22

Start #4 thread(s)

Fail: angle_err: 2.22687

21 : 22

Pair **size:** 56

q vector: 0.0294919

0.413663

-0.0801259

0.906418

matrix T:

-0.656026 -0.119754 0.745177 0.557431

-0.0128264 -0.98542 -0.169655 0.712637

0.754629 -0.120856 0.644925 -0.671365

0 0 0 1

```
add: 23
Start #4 thread(s)
Fail: angle_err: 0.878103
20 : 23
Fail: angle_err: 0.610793
18 : 23
Pair size: 59
q vector: 0.0379497
  0.431417
-0.0812316
  0.897686
matrix T:
  -0.624879  -0.138223  0.768388  0.57306
-0.00195545 -0.983923 -0.178585  0.825826
  0.780719  -0.113097  0.614562 -0.644356
      0      0      0      1
```

```
add: 24
Start #4 thread(s)
Fail: angle_err: 0.676762
21 : 24
Fail: angle_err: 0.623781
20 : 24
Pair size: 62
q vector: 0.0384345
  0.432476
-0.0812438
  0.897155
matrix T:
  -0.622975  -0.139235  0.76975  0.567426
-0.00130854 -0.983844 -0.17902  0.852448
  0.782241  -0.112533  0.612728 -0.640255
      0      0      0      1
```

```
add: 25
Start #4 thread(s)
Fail: angle_err: 1.74922
21 : 25
Fail: angle_err: 2.2529
20 : 25
Pair size: 65
q vector: 0.0383352
  0.432287
-0.0811942
  0.897255
matrix T:
  -0.623318  -0.138991  0.769517  0.565736
-0.00140532 -0.983876 -0.178847  0.821018
  0.781968  -0.11256  0.613072 -0.624082
      0      0      0      1
```

```
add: 26
Start #4 thread(s)
Fail: angle_err: 0.576873
25 : 26
Fail: angle_err: 1.36306
24 : 26
Fail: angle_err: 2.80055
23 : 26
Fail: angle_err: 1.29297
22 : 26
Fail: angle_err: 1.74589
21 : 26
Pair size: 65
q vector: 0.0383352
  0.432287
-0.0811942
```

```
0.897255
matrix T:
-0.623318 -0.138991 0.769517 0.565736
-0.00140532 -0.983876 -0.178847 0.821018
0.781968 -0.11256 0.613072 -0.624082
0 0 0 1
```

add: 27

```
Start #4 thread(s)
Fail: angle_err: 1.50654
23 : 27
Fail: angle_err: 2.63729
22 : 27
Pair size: 68
q vector: 0.0384723
0.432681
-0.0812853
0.89705
```

```
matrix T:
-0.622614 -0.139364 0.770019 0.564545
-0.00131809 -0.983825 -0.179126 0.825111
0.782528 -0.112542 0.612359 -0.620089
0 0 0 1
```

add: 28

```
Start #4 thread(s)
Fail: angle_err: 1.44738
25 : 28
Fail: angle_err: 3.12361
23 : 28
Pair size: 71
q vector: 0.0385203
0.432837
-0.0812941
0.896973
```

```
matrix T:
-0.622337 -0.139477 0.770222 0.558612
-0.00127081 -0.983815 -0.179183 0.809094
0.782748 -0.112491 0.612087 -0.605483
0 0 0 1
```

add: 29

```
Start #4 thread(s)
Fail: angle_err: 0.740907
27 : 29
Fail: angle_err: 1.47678
25 : 29
Fail: angle_err: 2.20272
24 : 29
Pair size: 73
q vector: 0.0386212
0.433315
-0.0813144
0.896735
```

```
matrix T:
-0.621493 -0.139736 0.770857 0.554887
-0.0012034 -0.983793 -0.179305 0.786075
0.783419 -0.112365 0.611252 -0.596011
0 0 0 1
```

add: 30

```
Start #4 thread(s)
Fail: angle_err: 0.672083
27 : 30
Pair size: 77
q vector: 0.0382541
0.432204
-0.0810779
```



```
0.897308
matrix T:
-0.623472 -0.138736 0.769438 0.55072
-0.00143295 -0.983926 -0.178571 0.780779
0.781844 -0.112437 0.613252 -0.588748
0 0 0 1
```

add: 31

```
Start #4 thread(s)
Fail: angle_err: 2.45307
26 : 31
Pair size: 81
```

q vector: 0.0379062

```
0.43119
-0.0808607
0.897831
```

```
matrix T:
-0.625277 -0.137799 0.768141 0.543013
-0.00166589 -0.984049 -0.177888 0.780206
0.780401 -0.112509 0.615074 -0.578654
0 0 0 1
```

add: 32

```
Start #4 thread(s)
Fail: angle_err: 4.43986
27 : 32
Pair size: 85
```

q vector: 0.0378002

```
0.431009
-0.0807342
0.897933
```

```
matrix T:
-0.625605 -0.137478 0.767931 0.537148
-0.00171028 -0.984106 -0.177572 0.773874
0.780138 -0.112403 0.615426 -0.56805
0 0 0 1
```

add: 33

```
Start #4 thread(s)
Pair size: 90
```

q vector: 0.0389046

```
0.434805
-0.0814356
0.89599
```

```
matrix T:
-0.618861 -0.140534 0.772827 0.522351
-0.00110098 -0.983709 -0.179763 0.78148
0.785499 -0.112099 0.608625 -0.537086
0 0 0 1
```

add: 34

```
Start #4 thread(s)
Fail: angle_err: 1.12751
33 : 34
Fail: angle_err: 1.67098
31 : 34
```

Pair **size:** 93

q vector: 0.0390956

```
0.435456
-0.0815059
0.89566
```

```
matrix T:
-0.617699 -0.141017 0.773668 0.512321
-0.000951803 -0.983657 -0.180052 0.75514
0.786414 -0.111954 0.60747 -0.517745
0 0 0 1
```

add: 35

```

Start #4 thread(s)
Fail: angle_err: 0.52837
34 : 35
Fail: angle_err: 0.832947
33 : 35
Pair size: 96
q vector: 0.0389319
  0.434975
-0.0813594
  0.895914
matrix T:
  -0.618563  -0.140538   0.773065   0.495804
-0.00101938  -0.98373  -0.179651   0.725965
  0.785735  -0.111913   0.608355  -0.505738
      0      0      0      1

add: 36
Start #4 thread(s)
Pair size: 101
q vector: 0.0392576
  0.434849
-0.0812498
  0.895971
matrix T:
  -0.61873  -0.14101   0.772845   0.472141
-0.000315374  -0.983715  -0.179737   0.659429
  0.785603  -0.111453   0.608609  -0.490994
      0      0      0      1

add: 37
Start #4 thread(s)
Fail: angle_err: 1.21096
33 : 37
Fail: angle_err: 3.78146
32 : 37
Pair size: 104
q vector: 0.0399879
  0.434744
-0.0812713
  0.895987
matrix T:
  -0.618797  -0.142322   0.772551   0.4684
0.000992925  -0.983592  -0.180405   0.643751
  0.785551  -0.110867   0.608785  -0.487406
      0      0      0      1

add: 38
Start #4 thread(s)
Fail: angle_err: 1.32226
36 : 38
Fail: angle_err: 0.874532
35 : 38
Fail: angle_err: 0.760421
33 : 38
Pair size: 106
q vector: 0.0404233
  0.435206
-0.0814586
  0.895727
matrix T:
  -0.617923  -0.143319   0.773066   0.464459
0.00151393  -0.983461  -0.181114   0.634112
  0.786237  -0.110744   0.60792  -0.483962
      0      0      0      1

add: 39
Start #4 thread(s)
Fail: angle_err: 0.713517

```

```
37 : 39
Fail: angle_err: 2.07201
34 : 39
Pair size: 109
q vector:0.0410132
  0.436128
-0.081826
  0.895218
matrix T:
-0.616221 -0.144805  0.774147  0.463804
0.00205831 -0.983245 -0.182278  0.636728
  0.787571 -0.11073  0.606194 -0.471178
      0      0      0      1
```

```
add: 40
Start #4 thread(s)
Fail: angle_err: 0.618551
39 : 40
Fail: angle_err: 0.956541
38 : 40
Fail: angle_err: 1.28412
37 : 40
Pair size: 111
q vector: 0.0414315
  0.435253
-0.0816224
  0.895643
matrix T:
-0.617676 -0.145268  0.772899  0.469256
0.00316278 -0.983242 -0.182275  0.645449
  0.786426 -0.110143  0.607785 -0.469907
      0      0      0      1
```

```
add: 41
Start #4 thread(s)
Fail: angle_err: 0.604003
40 : 41
Fail: angle_err: 1.65949
38 : 41
Fail: angle_err: 1.56007
37 : 41
Fail: angle_err: 1.36343
36 : 41
Pair size: 112
q vector: 0.041369
  0.435235
-0.0816027
  0.895656
matrix T:
-0.617718 -0.145137  0.77289  0.468993
0.00307206 -0.983259 -0.182186  0.643806
  0.786394 -0.110165  0.607823 -0.468365
      0      0      0      1
```

```
add: 42
Start #4 thread(s)
Fail: angle_err: 0.6474
41 : 42
Fail: angle_err: 1.70099
40 : 42
Fail: angle_err: 1.25512
39 : 42
Fail: angle_err: 2.49429
38 : 42
Fail: angle_err: 2.50243
37 : 42
Pair size: 112
q vector: 0.041369
```

```
0.435235
-0.0816027
0.895656
matrix T:
-0.617718 -0.145137 0.77289 0.468993
0.00307206 -0.983259 -0.182186 0.643806
0.786394 -0.110165 0.607823 -0.468365
0 0 0 1
```

add: 43

```
Start #4 thread(s)
Fail: angle_err: 2.73586
42 : 43
Fail: angle_err: 1.68732
41 : 43
Fail: angle_err: 1.19366
40 : 43
Fail: angle_err: 1.12946
39 : 43
Pair size: 113
q vector: 0.0412973
```

```
0.433965
-0.0812181
0.89631
matrix T:
-0.619937 -0.144522 0.771227 0.472148
0.00353865 -0.983396 -0.181436 0.641139
0.784643 -0.10975 0.610156 -0.469509
0 0 0 1
```

add: 44

```
Start #4 thread(s)
Fail: angle_err: 2.6496
42 : 44
Fail: angle_err: 1.41852
41 : 44
Fail: angle_err: 0.788382
40 : 44
Fail: angle_err: 1.19977
39 : 44
Pair size: 114
q vector: 0.0412922
```

```
0.433998
-0.0812252
0.896294
matrix T:
-0.619882 -0.144523 0.771271 0.471746
0.0035168 -0.983395 -0.181445 0.639927
0.784687 -0.109762 0.610097 -0.4685
0 0 0 1
```

add: 45

```
Start #4 thread(s)
Fail: angle_err: 1.08418
44 : 45
Fail: angle_err: 1.08872
43 : 45
Fail: angle_err: 1.6611
42 : 45
Fail: angle_err: 0.590658
41 : 45
Pair size: 115
q vector: 0.0412401
```

```
0.433281
-0.0809965
0.896664
matrix T:
-0.621134 -0.144146 0.770334 0.473482
```

```
0.0037686 -0.983478 -0.18099 0.63784
0.783696 -0.109516 0.611414 -0.464474
0 0 0 1
```

add: 46

Start #4 thread(s)

Fail: angle_err: 0.900503

44 : 46

Fail: angle_err: 1.18565

43 : 46

Fail: angle_err: 1.35154

42 : 46

Pair **size:** 117

q vector: 0.0409168

0.432423

-0.0806635

0.897123

matrix T:

-0.622673 -0.143176 0.769272 0.470988

0.00365344 -0.983638 -0.180117 0.616395

0.782474 -0.109343 0.613008 -0.462894

0 0 0 1

add: 47

Start #4 thread(s)

Fail: angle_err: 0.635312

42 : 47

Pair **size:** 121

q vector: 0.0407497

0.431987

-0.0805239

0.897353

matrix T:

-0.623454 -0.142704 0.768727 0.471047

0.00356327 -0.983711 -0.179723 0.605206

0.781852 -0.10931 0.613807 -0.460403

0 0 0 1

add: 48

Start #4 thread(s)

Fail: angle_err: 0.849888

47 : 48

Fail: angle_err: 0.987781

43 : 48

Pair **size:** 124

q vector: 0.0415615

0.43222

-0.0808859

0.897171

matrix T:

-0.622916 -0.144497 0.768828 0.474824

0.0046544 -0.98346 -0.181064 0.634941

0.782275 -0.10921 0.613286 -0.458292

0 0 0 1

add: 49

Start #4 thread(s)

Fail: angle_err: 1.04907

47 : 49

Fail: angle_err: 0.696929

44 : 49

Pair **size:** 127

q vector: 0.0420847

0.432042

-0.0810711

0.897216

matrix T:

-0.623137 -0.14557 0.768446 0.47542

```
0.00546575 -0.983313 -0.181841 0.639082
0.782094 -0.109112 0.613534 -0.466031
0 0 0 1
```

add: 50

Start #4 thread(s)

Fail: angle_err: 0.53732

49 : 50

Pair **size:** 131

q vector:0.0420226

0.431836

-0.081037

0.897321

matrix T:

```
-0.623504 -0.145405 0.76818 0.476219
0.00542614 -0.983334 -0.181726 0.646432
0.781802 -0.109139 0.613901 -0.463913
0 0 0 1
```

add: 51

Start #4 thread(s)

Fail: angle_err: 0.696495

49 : 51

Pair **size:** 135

q vector: 0.0414322

0.431072

-0.0807486

0.897741

matrix T:

```
-0.62492 -0.144008 0.767292 0.473126
0.00477388 -0.983526 -0.180703 0.602268
0.780674 -0.109262 0.615313 -0.461031
0 0 0 1
```

add: 52

Start #4 thread(s)

Fail: angle_err: 0.667209

50 : 52

Pair **size:** 139

q vector: 0.0416489

0.430469

-0.0807658

0.898019

matrix T:

```
-0.625924 -0.144337 0.766411 0.480951
0.00526864 -0.983485 -0.180916 0.652653
0.779866 -0.109201 0.616347 -0.466327
0 0 0 1
```

add: 53

Start #4 thread(s)

Pair **size:** 144

q vector: 0.0415363

0.430487

-0.0807146

0.89802

matrix T:

```
-0.625911 -0.144094 0.766467 0.48044
0.00510773 -0.98352 -0.180728 0.642706
0.779878 -0.109205 0.616332 -0.465622
0 0 0 1
```

add: 54

Start #4 thread(s)

Fail: angle_err: 0.877643

51 : 54

Fail: angle_err: 0.566259

50 : 54

```
Pair size: 147
q vector: 0.0414923
  0.430785
-0.0807443
  0.897877
matrix T:
-0.625405 -0.144077  0.766884  0.478247
0.00494303 -0.983518 -0.180745  0.634469
  0.780285 -0.109248  0.615809 -0.463955
      0      0      0      1
```

```
add: 55
Start #4 thread(s)
Fail: angle_err: 1.00721
54 : 55
```

```
Pair size: 151
q vector: 0.0417931
  0.430762
-0.0808647
  0.897863
matrix T:
-0.625394 -0.144716  0.766772  0.481785
0.00538191 -0.983428 -0.181217  0.66102
  0.780291 -0.109205  0.615809 -0.461757
      0      0      0      1
```

```
add: 56
Start #4 thread(s)
Fail: angle_err: 1.12426
54 : 56
Fail: angle_err: 0.512186
53 : 56
```

```
Pair size: 154
q vector: 0.042771
  0.430285
-0.081234
  0.898013
matrix T:
-0.626052 -0.146725  0.765853  0.493585
0.00691022 -0.983143 -0.182706  0.733824
  0.779751 -0.109091  0.616512 -0.452973
      0      0      0      1
```

```
add: 57
Start #4 thread(s)
Fail: angle_err: 1.89204
56 : 57
Fail: angle_err: 0.825746
55 : 57
```

```
Pair size: 157
q vector: 0.0430735
  0.43034
-0.0813795
  0.897959
matrix T:
-0.625905 -0.147398  0.765844  0.497841
0.00731484 -0.983044 -0.183223  0.763151
  0.779865 -0.109078  0.61637 -0.448316
      0      0      0      1
```

```
add: 58
Start #4 thread(s)
Fail: angle_err: 1.43395
57 : 58
Fail: angle_err: 0.670725
54 : 58
Pair size: 160
q vector: 0.0437657
```

```
0.430267
-0.0816589
0.897935
matrix T:
-0.62591 -0.148868 0.765555 0.503566
0.00832739 -0.982833 -0.184311 0.806542
0.77985 -0.108987 0.616405 -0.4447
0 0 0 1
```

add: 59

```
Start #4 thread(s)
Fail: angle_err: 1.15981
57 : 59
Pair size: 164
q vector: 0.0448536
```

```
0.431019
-0.0822313
0.897468
matrix T:
-0.624421 -0.151396 0.766275 0.514324
0.0096229 -0.982452 -0.186265 0.895196
0.781028 -0.108934 0.614921 -0.432879
0 0 0 1
```

add: 60

```
Start #4 thread(s)
Fail: angle_err: 0.713999
59 : 60
Fail: angle_err: 0.569948
55 : 60
Pair size: 167
q vector: 0.0448966
```

```
0.431025
-0.0822514
0.897461
matrix T:
-0.624403 -0.151491 0.766271 0.511842
0.00968106 -0.982438 -0.186338 0.882458
0.781042 -0.108932 0.614904 -0.43024
0 0 0 1
```

add: 61

```
Start #4 thread(s)
Fail: angle_err: 0.567575
59 : 61
Fail: angle_err: 0.523917
57 : 61
Pair size: 170
q vector: 0.0449196
```

```
0.431036
-0.0822621
0.897454
matrix T:
-0.62438 -0.151542 0.766279 0.511611
0.00971067 -0.98243 -0.186377 0.880385
0.78106 -0.108929 0.614882 -0.426575
0 0 0 1
```

add: 62

```
Start #4 thread(s)
Fail: angle_err: 0.510941
58 : 62
Pair size: 174
q vector: 0.0456766
```

```
0.431756
-0.0826729
0.897031
matrix T:
```



```
-0.623001 -0.153336 0.767045 0.516007
0.0105577 -0.982158 -0.187763 0.925243
 0.78215 -0.108878 0.613504 -0.417499
      0      0      0      1
```

add: 63

Start #4 thread(s)

Pair **size:** 179

q vector: 0.0456151

0.431604

-0.0826293

0.897112

matrix T:

```
-0.623275 -0.15317 0.766856 0.516242
0.0105174 -0.982183 -0.187631 0.925196
 0.781932 -0.10888 0.613781 -0.417047
      0      0      0      1
```

add: 64

Start #4 thread(s)

Fail: angle_err: 0.692811

63 : 64

Pair **size:** 183

q vector:0.0459563

0.431784

-0.082754

0.896996

matrix T:

```
-0.622901 -0.153909 0.767012 0.517363
0.0109815 -0.98208 -0.188147 0.945827
 0.782224 -0.108774 0.613428 -0.418666
      0      0      0      1
```

add: 65

Start #4 thread(s)

Pair **size:** 188

q vector: 0.0462865

0.432042

-0.0828963

0.896842

matrix T:

```
-0.622395 -0.154653 0.767272 0.518081
 0.011394 -0.981972 -0.188685 0.960702
 0.78262 -0.108694 0.612936 -0.417337
      0      0      0      1
```

add: 66

Start #4 thread(s)

Pair **size:** 193

q vector: 0.0461771

0.43199

-0.0828491

0.896877

matrix T:

```
-0.622504 -0.15441 0.767233 0.516893
0.0112503 -0.982007 -0.188507 0.939798
 0.782535 -0.108715 0.613041 -0.413588
      0      0      0      1
```

add: 67

Start #4 thread(s)

Fail: angle_err: 1.07919

66 : 67

Fail: angle_err: 0.634202

65 : 67

Pair **size:** 196

q vector: 0.0464912

0.432176

```
-0.0829622
  0.896761
matrix T:
-0.622125 -0.155091  0.767403  0.517079
0.0116744 -0.981912 -0.188979  0.965106
  0.782831 -0.10861  0.612682 -0.414868
          0         0         0         1
```

add: 68

Start #4 thread(s)

Fail: angle_err: 0.684433

66 : 68

Fail: angle_err: 0.819138

63 : 68

Pair **size:** 199

q vector: 0.0465476

0.432219

-0.0829782

0.896736

matrix T:

```
-0.62204 -0.155211  0.767448  0.517006
0.0117522 -0.981896 -0.189057  0.967788
  0.782897 -0.108582  0.612602 -0.414396
          0         0         0         1
```

add: 69

Start #4 thread(s)

Fail: angle_err: 1.1303

68 : 69

Fail: angle_err: 1.0188

67 : 69

Fail: angle_err: 2.25353

66 : 69

Fail: angle_err: 2.00431

65 : 69

Fail: angle_err: 1.41889

64 : 69

Pair **size:** 199

q vector: 0.0465476

0.432219

-0.0829782

0.896736

matrix T:

```
-0.62204 -0.155211  0.767448  0.517006
0.0117522 -0.981896 -0.189057  0.967788
  0.782897 -0.108582  0.612602 -0.414396
          0         0         0         1
```

add: 70

Start #4 thread(s)

Fail: angle_err: 1.12084

69 : 70

Pair **size:** 203

q vector: 0.0471447

0.432733

-0.0832476

0.896431

matrix T:

```
-0.621039 -0.156572  0.767982  0.519923
  0.012476 -0.981694 -0.190054  1.00503
  0.78368 -0.108449  0.611624 -0.411575
          0         0         0         1
```

add: 71

Start #4 thread(s)

Fail: angle_err: 0.642056

68 : 71

Fail: angle_err: 0.84272

```
66 : 71
Pair size: 206
q vector: 0.04745
0.432903
-0.0833833
0.89632
matrix T:
-0.620686 -0.157255 0.768127 0.523446
0.0128669 -0.981591 -0.190559 1.03152
0.783953 -0.108394 0.611284 -0.407528
0 0 0 1
```

```
add: 72
Start #4 thread(s)
Fail: angle_err: 0.829234
```

```
68 : 72
Fail: angle_err: 0.565871
```

```
67 : 72
Pair size: 209
q vector: 0.0477596
0.433228
-0.0835576
0.896131
matrix T:
-0.620064 -0.157997 0.768477 0.527568
0.0131986 -0.981474 -0.191139 1.05325
0.78444 -0.108375 0.610663 -0.40011
0 0 0 1
```

```
add: 73
Start #4 thread(s)
Pair size: 214
q vector: 0.0487298
```

```
0.433952
-0.0840172
0.895685
matrix T:
-0.618622 -0.160212 0.769181 0.533256
0.0143741 -0.981133 -0.192799 1.10292
0.785557 -0.108213 0.609253 -0.387325
0 0 0 1
```

```
add: 74
Start #4 thread(s)
Fail: angle_err: 0.634395
73 : 74
```

```
Fail: angle_err: 0.584953
72 : 74
```

```
Fail: angle_err: 0.805785
70 : 74
```

```
Pair size: 216
q vector: 0.0489931
0.434295
-0.0841594
0.895491
matrix T:
-0.617975 -0.160846 0.769568 0.534322
0.0146458 -0.981034 -0.193283 1.11723
0.786061 -0.108173 0.60861 -0.381843
0 0 0 1
```

```
add: 75
Start #4 thread(s)
Fail: angle_err: 0.847672
70 : 75
```

```
Pair size: 220
q vector: 0.0495161
0.434844
```

```
-0.0844143
  0.895172
matrix T:
-0.616917 -0.162065  0.770161  0.537511
0.0152367 -0.980845 -0.194194  1.15383
  0.786881 -0.108067  0.607569 -0.376225
          0         0         0         1
```

add: 76

Start #4 thread(s)

Fail: angle_err: 0.514008

73 : 76

Fail: angle_err: 0.606441

71 : 76

Pair **size:** 223

q vector: 0.0496618

0.434914

-0.0844662

0.895125

matrix T:

```
-0.616767 -0.162378  0.770215  0.537042
0.0154359 -0.980798 -0.194413  1.15466
  0.786994 -0.108018  0.607431 -0.372932
          0         0         0         1
```

add: 77

Start #4 thread(s)

Fail: angle_err: 0.510543

76 : 77

Fail: angle_err: 0.509721

74 : 77

Pair **size:** 226

q vector: 0.0505116

0.435513

-0.0848597

0.894749

matrix T:

```
-0.615554 -0.164305  0.770777  0.54263
0.0164754 -0.980495 -0.195853  1.19482
  0.787922 -0.107859  0.606255 -0.358518
          0         0         0         1
```

add: 78

Start #4 thread(s)

Fail: angle_err: 0.592217

74 : 78

Fail: angle_err: 0.652247

73 : 78

Pair **size:** 229

q vector: 0.0505954

0.43558

-0.0848974

0.894708

matrix T:

```
-0.61542 -0.164495  0.770843  0.543704
0.0165769 -0.980465 -0.195994  1.20013
  0.788025 -0.10784  0.606125 -0.355419
          0         0         0         1
```

add: 79

Start #4 thread(s)

Fail: angle_err: 0.972054

76 : 79

Fail: angle_err: 1.00107

75 : 79

Fail: angle_err: 1.21741

74 : 79

Pair **size:** 231

```
q vector: 0.0505475
  0.435528
-0.0848747
  0.894738
matrix T:
-0.61552 -0.164384  0.770787  0.543738
0.0165229 -0.980482 -0.195911  1.19677
  0.787948 -0.107852  0.606223 -0.354252
      0      0      0      1
```

add: 80

```
Start #4 thread(s)
Fail: angle_err: 1.25096
79 : 80
Fail: angle_err: 0.739452
77 : 80
Fail: angle_err: 1.69529
76 : 80
```

Pair **size: 233**

```
q vector: 0.0505491
  0.435473
-0.0848748
  0.894765
matrix T:
-0.615615 -0.164381  0.770712  0.544679
0.0165376 -0.980482 -0.195912  1.19213
  0.787873 -0.10786  0.606318 -0.347619
      0      0      0      1
```

add: 81

```
Start #4 thread(s)
Fail: angle_err: 1.52894
79 : 81
Fail: angle_err: 1.28588
78 : 81
Fail: angle_err: 1.03041
77 : 81
Fail: angle_err: 2.09811
76 : 81
```

Pair **size: 234**

```
q vector: 0.0504963
  0.435396
-0.0848436
  0.894808
matrix T:
-0.61576 -0.16425  0.770624  0.544491
0.0164879 -0.980503 -0.195809  1.18966
  0.787761 -0.107866  0.606463 -0.348163
      0      0      0      1
```

add: 82

```
Start #4 thread(s)
Fail: angle_err: 0.87533
79 : 82
Fail: angle_err: 0.660383
78 : 82
```

Pair **size: 237**

```
q vector: 0.049795
  0.434837
-0.0845195
  0.89515
matrix T:
-0.616874 -0.162653  0.770072  0.542744
0.0156435 -0.980754 -0.194621  1.15714
  0.786906 -0.10801  0.607546 -0.343087
      0      0      0      1
```

add: 83

```
Start #4 thread(s)
Fail: angle_err: 0.752374
79 : 83
Pair size: 241
q vector:0.0490255
 0.433707
-0.084171
 0.895774
matrix T:
-0.61899 -0.160843  0.768753  0.541409
0.0148206 -0.981023 -0.193322  1.11629
 0.785259 -0.108271  0.609628 -0.335995
      0      0      0      1
```

```
add: 84
Start #4 thread(s)
Fail: angle_err: 0.651506
81 : 84
Pair size: 245
q vector:0.0469223
 0.431893
-0.083251
 0.896848
matrix T:
-0.622533 -0.156075  0.766872  0.53764
0.0122532 -0.981735 -0.189858  1.01153
 0.782497 -0.108796  0.613075 -0.317133
      0      0      0      1
```

```
add: 85
Start #4 thread(s)
Fail: angle_err: 0.619756
84 : 85
Pair size: 249
q vector: 0.0447515
 0.430123
-0.0823059
 0.897896
matrix T:
-0.625983 -0.151168  0.765045  0.536534
0.00956108 -0.982446 -0.186302  0.967961
 0.779778 -0.109307  0.61644 -0.298282
      0      0      0      1
```

```
add: 86
Start #4 thread(s)
Fail: angle_err: 0.715635
81 : 86
Pair size: 253
q vector: 0.0432977
 0.429499
-0.0817026
 0.898321
matrix T:
-0.627312 -0.147973  0.764581  0.531853
0.00760815 -0.9829 -0.183983  0.891764
 0.778731 -0.109598  0.61771 -0.285405
      0      0      0      1
```

```
add: 87
Start #4 thread(s)
Fail: angle_err: 0.519977
86 : 87
Fail: angle_err: 0.61791
84 : 87
Pair size: 256
q vector: 0.0423714
 0.42878
```

```
-0.0812982
  0.898745
matrix T:
-0.628705 -0.14588  0.763838  0.530812
0.0064441 -0.983191 -0.182469  0.866404
  0.777617 -0.109797  0.619077 -0.281885
          0         0         0         1

add: 88
Start #4 thread(s)
Fail: angle_err: 0.900945
86 : 88
Pair size: 260
q vector: 0.0415545
  0.428574
-0.0809596
  0.898912
matrix T:
-0.629195 -0.144102  0.763772  0.527446
0.0053134 -0.983438  -0.18117  0.834477
  0.777229 -0.109933  0.61954  -0.280188
          0         0         0         1

add: 89
Start #4 thread(s)
Fail: angle_err: 0.873455
86 : 89
Fail: angle_err: 0.85117
84 : 89
Pair size: 263
q vector: 0.0406781
  0.4283
-0.0805984
  0.899115
matrix T:
-0.629808 -0.142189  0.763625  0.522079
  0.004108 -0.983698 -0.179779  0.77833
  0.77674  -0.11009  0.620125 -0.278077
          0         0         0         1

add: 90
Start #4 thread(s)
Fail: angle_err: 1.35339
86 : 90
Fail: angle_err: 0.538428
85 : 90
Pair size: 266
q vector: 0.0406177
  0.428147
-0.0805447
  0.899196
matrix T:
 -0.63008  -0.142017  0.763433  0.520993
0.00407657 -0.983725  -0.179632  0.769894
  0.776519  -0.11007  0.620405  -0.279386
          0         0         0         1

add: 91
Start #4 thread(s)
Fail: angle_err: 0.596468
88 : 91
Pair size: 270
q vector: 0.0404341
  0.427829
-0.0804238
  0.899366
matrix T:
 -0.630654  -0.141545  0.763047  0.519357
```

```
0.00391477 -0.983794 -0.179259 0.752518
0.776054 -0.110063 0.620988 -0.284651
0 0 0 1
```

add: 92

Start #4 thread(s)

Fail: angle_err: 0.993888

89 : 92

Fail: angle_err: 0.833931

88 : 92

Fail: angle_err: 1.13027

87 : 92

Pair **size:** 272

q vector: 0.0402467

0.427833

-0.0803529

0.899379

matrix T:

-0.630677 -0.141149 0.763101 0.518755

0.0036387 -0.983847 -0.178973 0.746445

0.776037 -0.110098 0.621004 -0.284511

0 0 0 1

add: 93

Start #4 thread(s)

Fail: angle_err: 0.697051

91 : 93

Fail: angle_err: 0.808634

90 : 93

Fail: angle_err: 1.19036

88 : 93

Pair **size:** 274

q vector: 0.0401124

0.427839

-0.0802954

0.899387

matrix T:

-0.63069 -0.14086 0.763144 0.519196

0.00344617 -0.983887 -0.178757 0.749321

0.776027 -0.11011 0.621013 -0.283747

0 0 0 1

add: 94

Start #4 thread(s)

Fail: angle_err: 0.885588

92 : 94

Pair **size:** 278

q vector: 0.0391261

0.42784

-0.0799331

0.899463

matrix T:

-0.630844 -0.138782 0.763397 0.51627

0.00198784 -0.98416 -0.177273 0.714783

0.775907 -0.110314 0.621128 -0.276502

0 0 0 1

add: 95

Start #4 thread(s)

Pair **size:** 283

q vector:0.0373906

0.42789

-0.079352

0.899564

matrix T:

-0.631024 -0.135178 0.763895 0.509182

-0.000637526 -0.98461 -0.174762 0.588717

0.775763 -0.110766 0.621226 -0.26075

0 0 0 1

```
add: 96
Start #4 thread(s)
Fail: angle_err: 1.3706
93 : 96
Fail: angle_err: 0.582464
92 : 96
Pair size: 286
q vector: 0.0369013
  0.428143
-0.0791939
  0.899478
matrix T:
  -0.630665  -0.134196  0.764365  0.510164
-0.00142876 -0.984733 -0.174064  0.578792
  0.776054  -0.110868  0.620845 -0.249713
      0      0      0      1

add: 97
Start #4 thread(s)
Pair size: 291
q vector: 0.037014
  0.428051
-0.0791968
  0.899517
matrix T:
  -0.630804  -0.13439  0.764215  0.510602
-0.00121119 -0.984716 -0.174165  0.579471
  0.775941  -0.11079  0.621 -0.249903
      0      0      0      1

add: 98
Start #4 thread(s)
Fail: angle_err: 0.920446
93 : 98
Pair size: 295
q vector:0.0375484
  0.428003
-0.079425
  0.899497
matrix T:
  -0.630807  -0.135538  0.764011  0.515013
-0.000438915 -0.984564 -0.175027  0.609981
  0.77594  -0.110743  0.62101 -0.243589
      0      0      0      1

add: 99
Start #4 thread(s)
Pair size: 300
q vector: 0.0383879
  0.428073
-0.0798654
  0.89939
matrix T:
  -0.63056  -0.137428  0.763877  0.523498
0.000674829 -0.984296 -0.176526  0.65833
  0.77614  -0.110795  0.62075 -0.232022
      0      0      0      1

poses #100 to record
pairs valid #300
pairs removed # 172 to record
pose record done
pair record done
----end----
```

optimization step

method: dogbox loss: soft_l1

Iteration	Total nfev	Cost	Cost reduction	Step norm	Optimality
0	1	2.0054e+04			7.39e+05
1	3	1.3144e+04	6.91e+03	3.73e-01	1.28e+06
2	4	1.1538e+04	1.61e+03	4.27e-01	4.60e+05
3	5	1.0994e+04	5.44e+02	1.57e-01	3.14e+04
4	6	1.0987e+04	6.65e+00	2.40e-02	1.80e+03
5	7	1.0987e+04	1.25e-02	6.71e-04	3.38e+00
6	8	1.0987e+04	8.14e-06	4.11e-05	1.04e-01
7	9	1.0987e+04	7.91e-09	6.81e-07	3.52e-03

`ftol` termination condition is satisfied.

Function evaluations 9, initial cost 2.0054e+04, final cost 1.0987e+04, first-order optimality 3.52e-03.
inverse [q, t]= [-1.29059375 0.24935761 -2.77319416 0.6551874 0.64206224 0.03151724]