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1001548562

Computer Vision – Assignment 4

Problem 1

Kl

```
  186.9940         0  160.6481
         0  246.3474   30.4405
         0         0    1.0000
```

Kr

```
  179.7206         0  145.4806
         0  245.7430   19.0381
         0         0    1.0000
```

Tl

```
   1.0e+03 *
    0.0005   -0.0009   -0.0000
    0.0000    0.0000    0.0007
   -0.0006   -0.0004    0.0000
    0.0153    0.0015   -2.4895
```

Tr

```
   1.0e+03 *
    0.0007   -0.0007    0.0000
    0.0000    0.0000   -0.0007
    0.0005    0.0005    0.0000
   -0.0179   -0.0016    2.6258
```

P_hat

```
    1.6779    0.1254    0.0044    1.0000
    1.6809    0.1045    0.0046    1.0000
    1.6685    0.1955    0.0056    1.0000
    1.6667    0.2072    0.0052    1.0000
```

1.6440 0.3601 0.0042 1.0000

1.6427 0.3694 0.0043 1.0000

1.6272 0.4800 0.0052 1.0000

1.6307 0.4551 0.0049 1.0000

1.6341 0.4282 0.0041 1.0000

1.6195 0.5329 0.0049 1.0000

mean_error

1.0e+07 *

-0.0001 -3.2490 -0.0022

max_error

1.0e+07 *

-0.0000 -3.2490 -0.0022

min_error

1.0e+07 *

-0.0001 -3.2490 -0.0022

std_error

36.4716 41.7154 0

Problem 2

SSD Time taken

300.4915

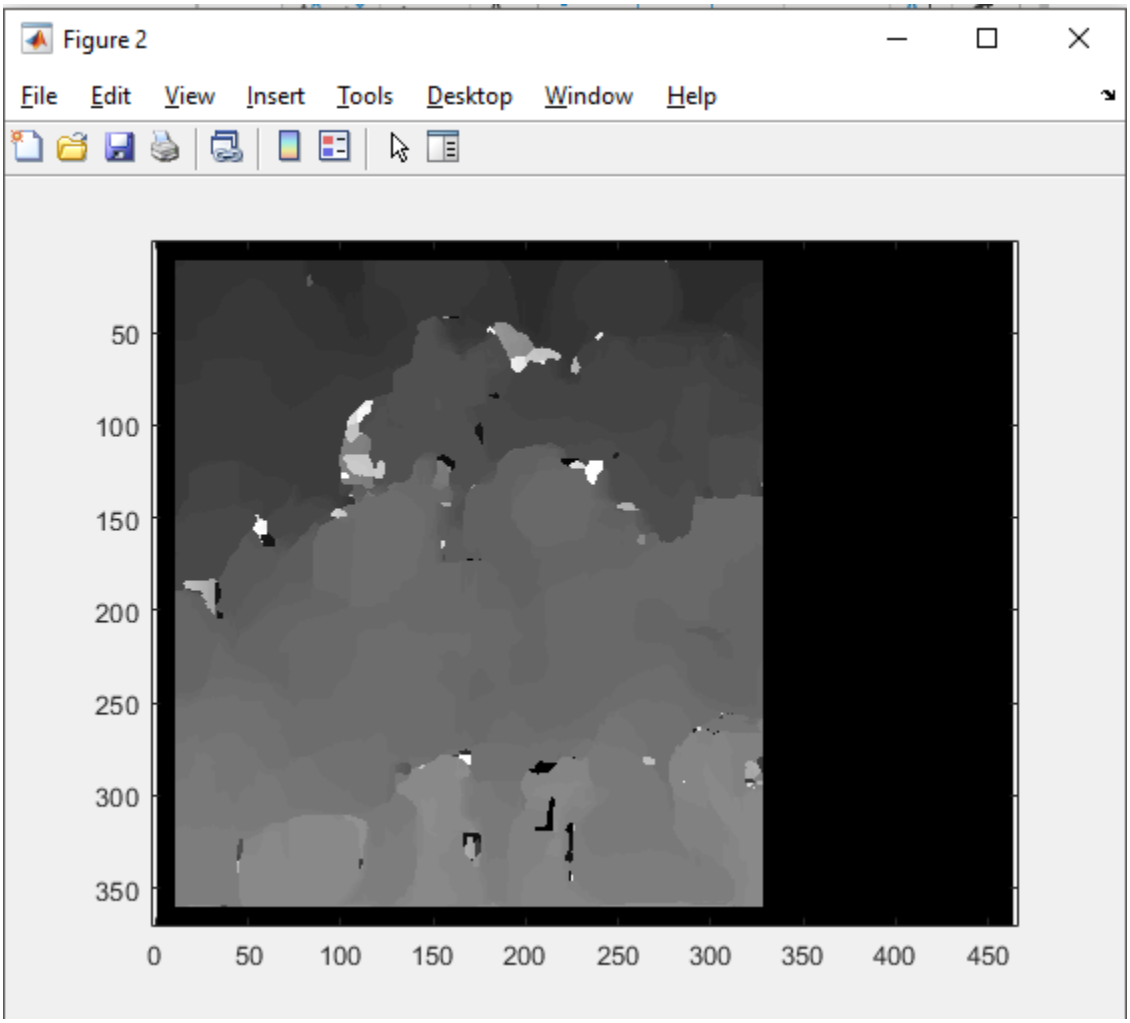
CC Time taken

416.4269

NCC Time taken

388.5497

NCC :



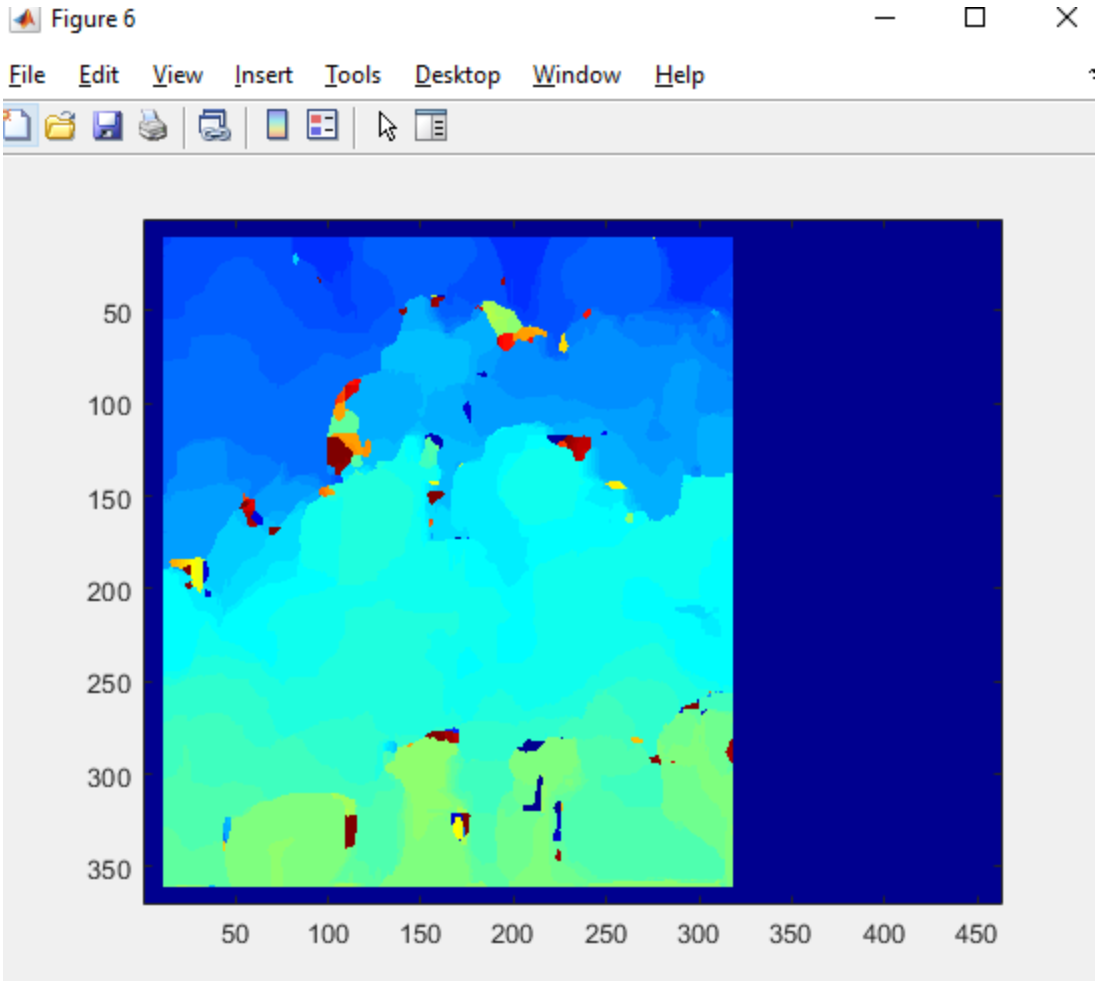


Figure 6
File Edit View Insert Tools Desktop Window Help
50
100
150
200
250
300
350
50 100 150 200 250 300 350 400 450

SSD

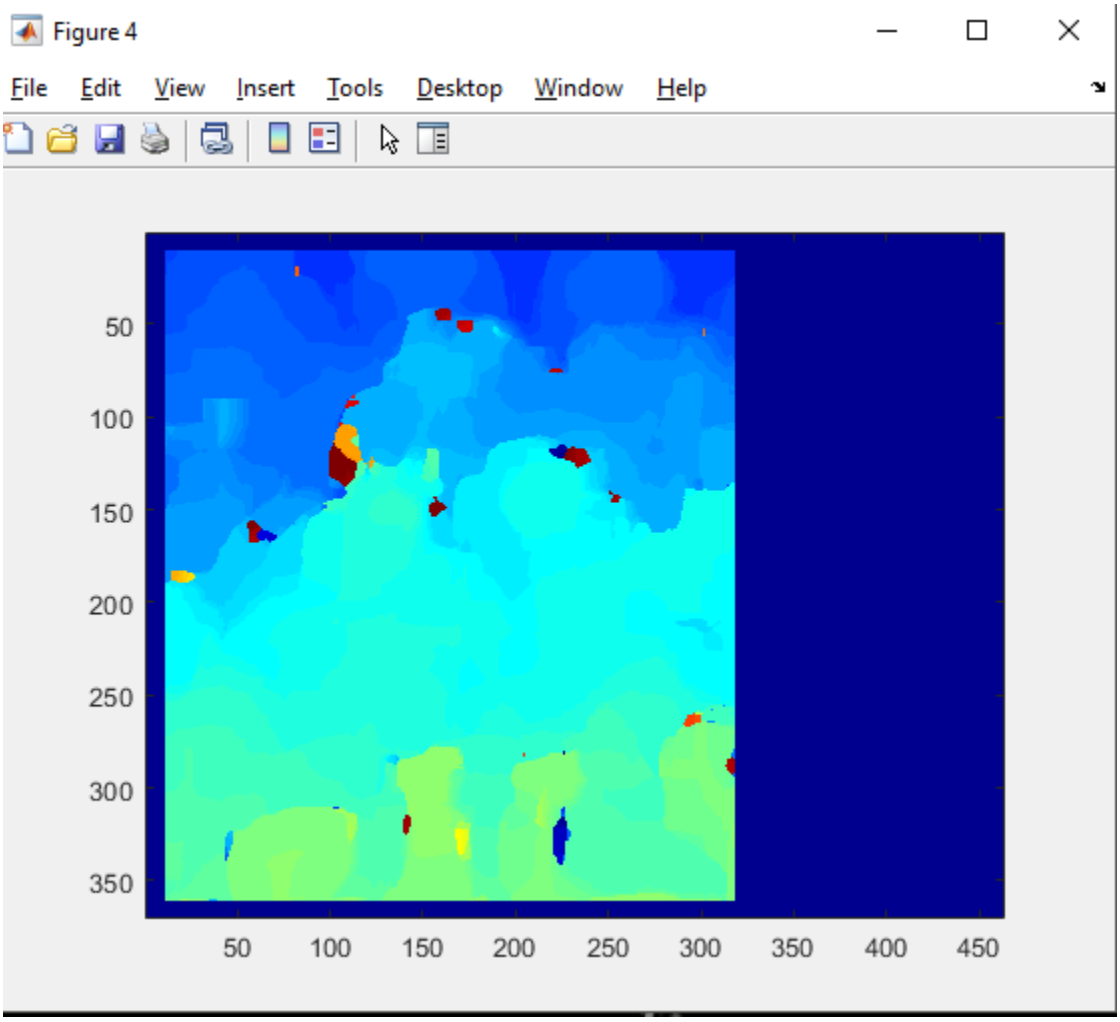


Figure 4
File Edit View Insert Tools Desktop Window Help
50
100
150
200
250
300
350
50 100 150 200 250 300 350 400 450

CC

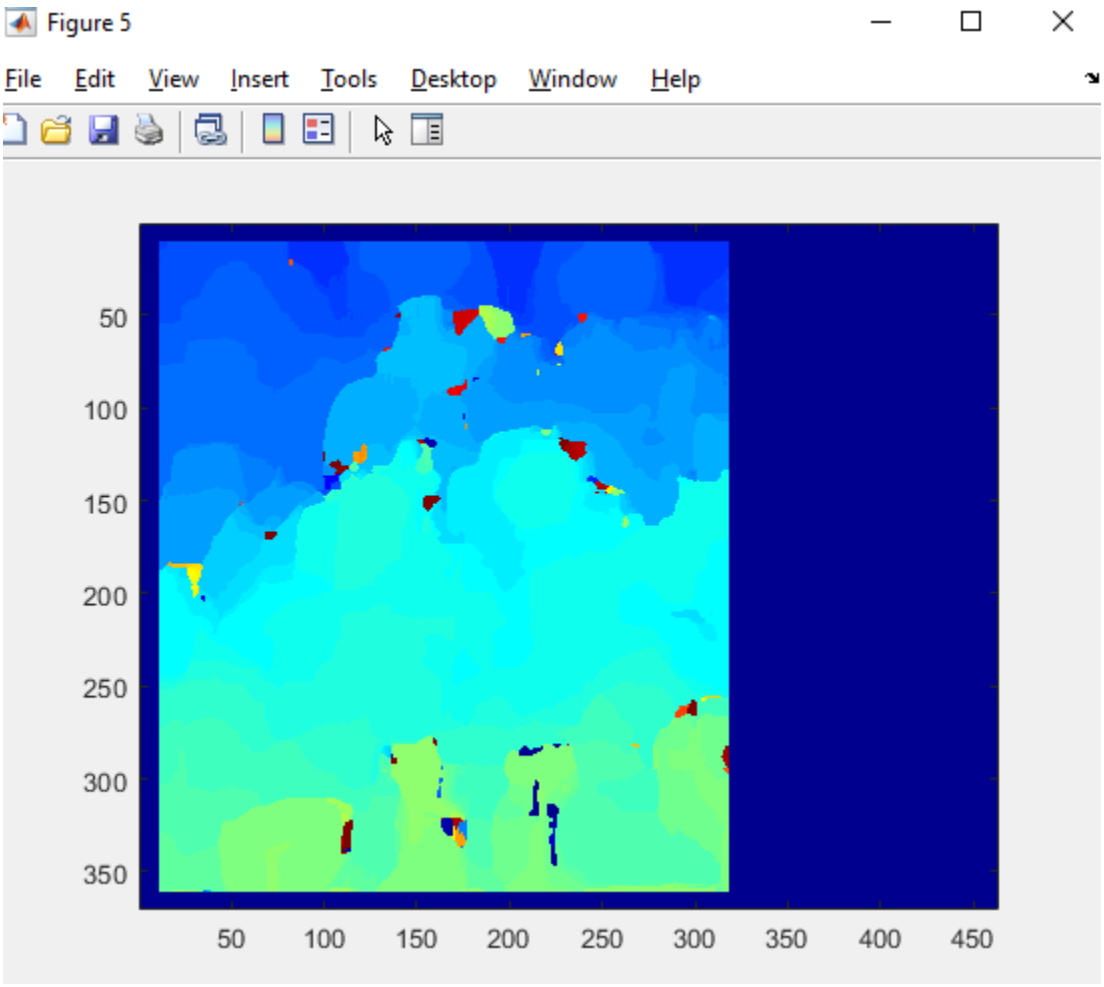


Figure 5
File Edit View Insert Tools Desktop Window Help
50
100
150
200
250
300
350
50 100 150 200 250 300 350 400 450

Problem 3

Right camera:

Focal Length: fc = [819.46326 620.17865] +/- [42.42718 25.14625]

Principal point: cc = [449.87809 222.14286] +/- [46.14395 20.61687]

Skew: alpha_c = [0.00000] +/- [0.00000] => angle of pixel axes = 90.00000 +/- 0.00000 degrees

Distortion: kc = [0.32284 -0.32353 -0.00012 0.04869 0.00000] +/- [0.14474 0.31475 0.01628 0.03720 0.00000]

Pixel error: err = [0.79734 1.14548]

```
%-- Focal length:
fc = [ 819.463257320972957 ; 620.178647237926839 ];

%-- Principal point:
cc = [ 449.878086004020133 ; 222.142859228368053 ];

%-- Skew coefficient:
alpha_c = 0.000000000000000;

%-- Distortion coefficients:
kc = [ 0.322839383796259 ; -0.323527800787114 ; -0.000123114109761 ;
0.048694162194749 ; 0.000000000000000 ];

%-- Focal length uncertainty:
fc_error = [ 42.427182586095775 ; 25.146248666335410 ];

%-- Principal point uncertainty:
cc_error = [ 46.143954274725992 ; 20.616870203793550 ];

%-- Skew coefficient uncertainty:
alpha_c_error = 0.000000000000000;

%-- Distortion coefficients uncertainty:
kc_error = [ 0.144743768218149 ; 0.314750176892816 ; 0.016282608973948 ;
0.037203942797971 ; 0.000000000000000 ];

%-- Image size:
nx = 640;
ny = 480;


%-- Various other variables (may be ignored if you do not use the Matlab
Calibration Toolbox):
```

```
%-- Those variables are used to control which intrinsic parameters should be
optimized

n_ima = 23;                     % Number of calibration images
est_fc = [ 1 ; 1 ];               % Estimation indicator of the two focal
variables
est_aspect_ratio = 1;             % Estimation indicator of the aspect
ratio fc(2)/fc(1)
center_optim = 1;                 % Estimation indicator of the principal
point
est_alpha = 0;                    % Estimation indicator of the skew
coefficient
est_dist = [ 1 ; 1 ; 1 ; 1 ; 0 ];   % Estimation indicator of the distortion
coefficients


%-- Extrinsic parameters:
%-- The rotation (omc_kk) and the translation (Tc_kk) vectors for every
calibration image and their uncertainties

%-- Image #1:
omc_1 = [ 2.168244e+00 ; 1.917859e+00 ; -8.499669e-02 ];
Tc_1  = [ -3.559345e+02 ; -1.527115e+02 ; 1.117109e+03 ];
omc_error_1 = [ 3.262069e-02 ; 3.989573e-02 ; 1.007614e-01 ];
Tc_error_1  = [ 6.313030e+01 ; 3.860670e+01 ; 4.670917e+01 ];

%-- Image #3:
omc_3 = [ -2.136001e+00 ; -2.151597e+00 ; -1.877500e-01 ];
Tc_3  = [ -4.705369e+02 ; -1.479691e+02 ; 1.138093e+03 ];
omc_error_3 = [ 4.884363e-02 ; 3.774219e-02 ; 9.032076e-02 ];
Tc_error_3  = [ 6.428349e+01 ; 4.000617e+01 ; 5.279481e+01 ];

%-- Image #5:
omc_5 = [ 1.880460e+00 ; 1.170949e+00 ; 7.104268e-01 ];
Tc_5  = [ -4.674542e+02 ; -9.980899e+01 ; 1.125253e+03 ];
omc_error_5 = [ 3.807558e-02 ; 3.613477e-02 ; 6.242321e-02 ];
Tc_error_5  = [ 6.360593e+01 ; 3.957749e+01 ; 5.361204e+01 ];

%-- Image #7:
omc_7 = [ -2.422887e-01 ; -2.490484e+00 ; 5.492819e-01 ];
Tc_7  = [ -1.717058e+02 ; -1.228712e+02 ; 1.092851e+03 ];
omc_error_7 = [ 2.398476e-02 ; 5.242665e-02 ; 4.714592e-02 ];
Tc_error_7  = [ 6.120007e+01 ; 3.700431e+01 ; 4.323698e+01 ];

%-- Image #9:
omc_9 = [ 2.222365e+00 ; 1.920265e+00 ; 6.455438e-01 ];
Tc_9  = [ -1.450310e+02 ; -1.958757e+02 ; 1.196940e+03 ];
omc_error_9 = [ 5.709916e-02 ; 4.828891e-02 ; 7.862462e-02 ];
Tc_error_9  = [ 6.716960e+01 ; 4.102898e+01 ; 5.273772e+01 ];

%-- Image #11:
omc_11 = [ -1.810996e+00 ; -1.951310e+00 ; -1.059631e+00 ];
Tc_11  = [ -5.213776e+02 ; -5.075502e+02 ; 1.722221e+03 ];
omc_error_11 = [ 4.120058e-02 ; 4.452152e-02 ; 7.971566e-02 ];
Tc_error_11  = [ 1.005956e+02 ; 6.174846e+01 ; 8.141029e+01 ];
```

```
%-- Image #13:
omc_13 = [ -1.788442e+00 ; -1.889046e+00 ; -1.109273e+00 ];
Tc_13  = [ -4.442421e+02 ; -3.426003e+02 ; 1.264311e+03 ];
omc_error_13 = [ 3.427404e-02 ; 4.034211e-02 ; 7.144727e-02 ];
Tc_error_13  = [ 7.375471e+01 ; 4.534127e+01 ; 6.047753e+01 ];


%-- Image #15:
omc_15 = [ -1.813382e+00 ; -1.823492e+00 ; -1.023352e+00 ];
Tc_15  = [ -4.092340e+02 ; -2.106093e+02 ; 9.972072e+02 ];
omc_error_15 = [ 3.168660e-02 ; 3.777324e-02 ; 6.745979e-02 ];
Tc_error_15  = [ 5.784005e+01 ; 3.571045e+01 ; 4.870781e+01 ];

%-- Image #17:
omc_17 = [ -2.161581e+00 ; -2.206067e+00 ; -1.244185e-02 ];
Tc_17  = [ -3.255614e+02 ; -5.915184e+01 ; 7.025685e+02 ];
omc_error_17 = [ 4.302790e-02 ; 3.749267e-02 ; 7.703793e-02 ];
Tc_error_17  = [ 3.922446e+01 ; 2.488117e+01 ; 3.164579e+01 ];

%-- Image #19:
omc_19 = [ 1.628223e+00 ; 1.566659e+00 ; 1.155618e+00 ];
Tc_19  = [ -3.390489e+02 ; -1.098036e+02 ; 8.309478e+02 ];
omc_error_19 = [ 4.610176e-02 ; 3.840465e-02 ; 5.307551e-02 ];
Tc_error_19  = [ 4.724697e+01 ; 2.933392e+01 ; 3.913701e+01 ];

%-- Image #21:
omc_21 = [ 1.692401e+00 ; 1.490572e+00 ; -7.377240e-01 ];
Tc_21  = [ -2.687231e+02 ; 1.992400e+02 ; 1.347872e+03 ];
omc_error_21 = [ 3.017171e-02 ; 3.751420e-02 ; 7.231368e-02 ];
Tc_error_21  = [ 7.607131e+01 ; 4.600497e+01 ; 5.333394e+01 ];

%-- Image #23:
omc_23 = [ 1.894670e+00 ; 1.415109e+00 ; 1.534410e+00 ];
Tc_23  = [ -2.123739e+02 ; 1.244287e+02 ; 7.674437e+02 ];
omc_error_23 = [ 5.989475e-02 ; 2.872353e-02 ; 5.751159e-02 ];
Tc_error_23  = [ 4.341106e+01 ; 2.643070e+01 ; 3.821286e+01 ];
```

Left Camera:

Focal Length: fc = [843.92721 630.52661] +/- [46.13048 26.47939]

Principal point: cc = [496.65885 215.45769] +/- [51.01791 14.49326]

Skew: alpha_c = [0.00000] +/- [0.00000] => angle of pixel axes = 90.00000 +/- 0.00000 degrees

Distortion: kc = [0.13759 -0.01669 0.01093 0.06422 0.00000] +/- [0.12939 0.19911 0.01025 0.03050 0.00000]

Pixel error: err = [0.72423 1.15715]

```
% Intrinsic and Extrinsic Camera Parameters
%
% This script file can be directly executed under Matlab to recover the
camera intrinsic and extrinsic parameters.
```

```
% IMPORTANT: This file contains neither the structure of the calibration
objects nor the image coordinates of the calibration points.
%            All those complementary variables are saved in the complete
matlab data file Calib_Results.mat.
% For more information regarding the calibration model visit
http://www.vision.caltech.edu/bouguetj/calib_doc/


%-- Focal length:
fc = [ 843.927207119297464 ; 630.526611437049723 ];

%-- Principal point:
cc = [ 496.658850194734782 ; 215.457688598665868 ];

%-- Skew coefficient:
alpha_c = 0.000000000000000;

%-- Distortion coefficients:
kc = [ 0.137594662436931 ; -0.016686544912740 ; 0.010926849535245 ;
0.064222638579309 ; 0.000000000000000 ];

%-- Focal length uncertainty:
fc_error = [ 46.130477364786934 ; 26.479393860594520 ];

%-- Principal point uncertainty:
cc_error = [ 51.017907083175686 ; 14.493258920477949 ];

%-- Skew coefficient uncertainty:
alpha_c_error = 0.000000000000000;

%-- Distortion coefficients uncertainty:
kc_error = [ 0.129392504566134 ; 0.199106792509736 ; 0.010247446772879 ;
0.030495799102268 ; 0.000000000000000 ];

%-- Image size:
nx = 640;
ny = 480;


%-- Various other variables (may be ignored if you do not use the Matlab
Calibration Toolbox):
%-- Those variables are used to control which intrinsic parameters should be
optimized

n_ima = 23;                     % Number of calibration images
est_fc = [ 1 ; 1 ];                 % Estimation indicator of the two focal
variables
est_aspect_ratio = 1;               % Estimation indicator of the aspect
ratio fc(2)/fc(1)
center_optim = 1;                   % Estimation indicator of the principal
point
est_alpha = 0;                      % Estimation indicator of the skew
coefficient
```

```
est_dist = [ 1 ; 1 ; 1 ; 1 ; 0 ];   % Estimation indicator of the distortion
coefficients


%-- Extrinsic parameters:
%-- The rotation (omc_kk) and the translation (Tc_kk) vectors for every
calibration image and their uncertainties

%-- Image #1:
omc_1 = [ 2.267089e+00 ; 2.024319e+00 ; -1.711742e-01 ];
Tc_1  = [ -3.137892e+02 ; -1.420662e+02 ; 1.102937e+03 ];
omc_error_1 = [ 3.255327e-02 ; 4.054321e-02 ; 9.674978e-02 ];
Tc_error_1  = [ 6.686351e+01 ; 2.640892e+01 ; 4.375918e+01 ];

%-- Image #3:
omc_3 = [ -2.085311e+00 ; -2.172793e+00 ; -2.841092e-01 ];
Tc_3  = [ -4.166047e+02 ; -1.394910e+02 ; 1.099125e+03 ];
omc_error_3 = [ 4.292942e-02 ; 4.040618e-02 ; 8.415046e-02 ];
Tc_error_3  = [ 6.717804e+01 ; 2.681210e+01 ; 4.927978e+01 ];


%-- Image #5:
omc_5 = [ 1.828167e+00 ; 1.098044e+00 ; 7.943075e-01 ];
Tc_5  = [ -4.051311e+02 ; -8.174995e+01 ; 1.098725e+03 ];
omc_error_5 = [ 4.041172e-02 ; 3.876241e-02 ; 5.514364e-02 ];
Tc_error_5  = [ 6.688386e+01 ; 2.669022e+01 ; 5.019488e+01 ];


%-- Image #7:
omc_7 = [ -2.224962e+00 ; -1.835458e+00 ; 1.064142e+00 ];
Tc_7  = [ -3.187862e+02 ; -4.552423e+01 ; 1.205507e+03 ];
omc_error_7 = [ 5.558374e-02 ; 2.430484e-02 ; 6.471447e-02 ];
Tc_error_7  = [ 7.240561e+01 ; 2.887384e+01 ; 4.352816e+01 ];


%-- Image #9:
omc_9 = [ 2.146440e+00 ; 1.916587e+00 ; 6.556399e-01 ];
Tc_9  = [ -8.680809e+01 ; -1.875123e+02 ; 1.183222e+03 ];
omc_error_9 = [ 5.532517e-02 ; 4.601208e-02 ; 6.337206e-02 ];
Tc_error_9  = [ 7.187149e+01 ; 2.805686e+01 ; 5.252084e+01 ];

%-- Image #11:
omc_11 = [ -1.812428e+00 ; -1.987957e+00 ; -9.749750e-01 ];
Tc_11  = [ -4.971370e+02 ; -4.926658e+02 ; 1.674888e+03 ];
omc_error_11 = [ 3.881720e-02 ; 4.402059e-02 ; 7.950077e-02 ];
Tc_error_11  = [ 1.055553e+02 ; 4.169332e+01 ; 7.730902e+01 ];

%-- Image #13:
omc_13 = [ -1.798420e+00 ; -1.932905e+00 ; -1.014187e+00 ];
Tc_13  = [ -3.960726e+02 ; -3.256256e+02 ; 1.207644e+03 ];
omc_error_13 = [ 2.873852e-02 ; 3.998869e-02 ; 6.977493e-02 ];
Tc_error_13  = [ 7.589758e+01 ; 3.006125e+01 ; 5.583745e+01 ];

%-- Image #15:
```

```
omc_15 = [ -1.742397e+00 ; -1.843800e+00 ; -1.044092e+00 ];
Tc_15  = [ -3.464937e+02 ; -1.954279e+02 ; 9.402641e+02 ];
omc_error_15 = [ 2.325789e-02 ; 3.922684e-02 ; 6.340191e-02 ];
Tc_error_15  = [ 5.867013e+01 ; 2.340015e+01 ; 4.392405e+01 ];

%-- Image #17:
omc_17 = [ 2.193060e+00 ; 2.276616e+00 ; 5.574882e-02 ];
Tc_17  = [ -2.631994e+02 ; -5.562387e+01 ; 6.934639e+02 ];
omc_error_17 = [ 3.735590e-02 ; 3.865772e-02 ; 7.307198e-02 ];
Tc_error_17  = [ 4.180918e+01 ; 1.663494e+01 ; 2.929973e+01 ];

%-- Image #19:
omc_19 = [ 1.604723e+00 ; 1.549479e+00 ; 1.169453e+00 ];
Tc_19  = [ -2.885034e+02 ; -1.161820e+02 ; 8.275386e+02 ];
omc_error_19 = [ 5.013749e-02 ; 4.013561e-02 ; 4.309501e-02 ];
Tc_error_19  = [ 5.091813e+01 ; 2.014906e+01 ; 3.765011e+01 ];

%-- Image #21:
omc_21 = [ 1.694468e+00 ; 1.426703e+00 ; -6.719710e-01 ];
Tc_21  = [ -4.548117e+02 ; 2.111848e+02 ; 1.334934e+03 ];
omc_error_21 = [ 2.353205e-02 ; 4.039479e-02 ; 6.636664e-02 ];
Tc_error_21  = [ 8.131797e+01 ; 3.246047e+01 ; 5.385827e+01 ];

%-- Image #23:
omc_23 = [ 1.807616e+00 ; 1.412630e+00 ; 1.611937e+00 ];
Tc_23  = [ -3.545157e+02 ; 1.342697e+02 ; 7.638367e+02 ];
omc_error_23 = [ 6.447174e-02 ; 2.535329e-02 ; 4.743025e-02 ];
Tc_error_23  = [ 4.835458e+01 ; 1.890479e+01 ; 4.113618e+01 ];
```

Problem 5

xs and n_y parameters:

y intercept - 11.3271

slope - 2.0920

xs and n_y2 parameters:

y intercept - 29.6492

slope - 1.5784

RANSAC parameters

y intercept - 16.5081

slope - 2.7839

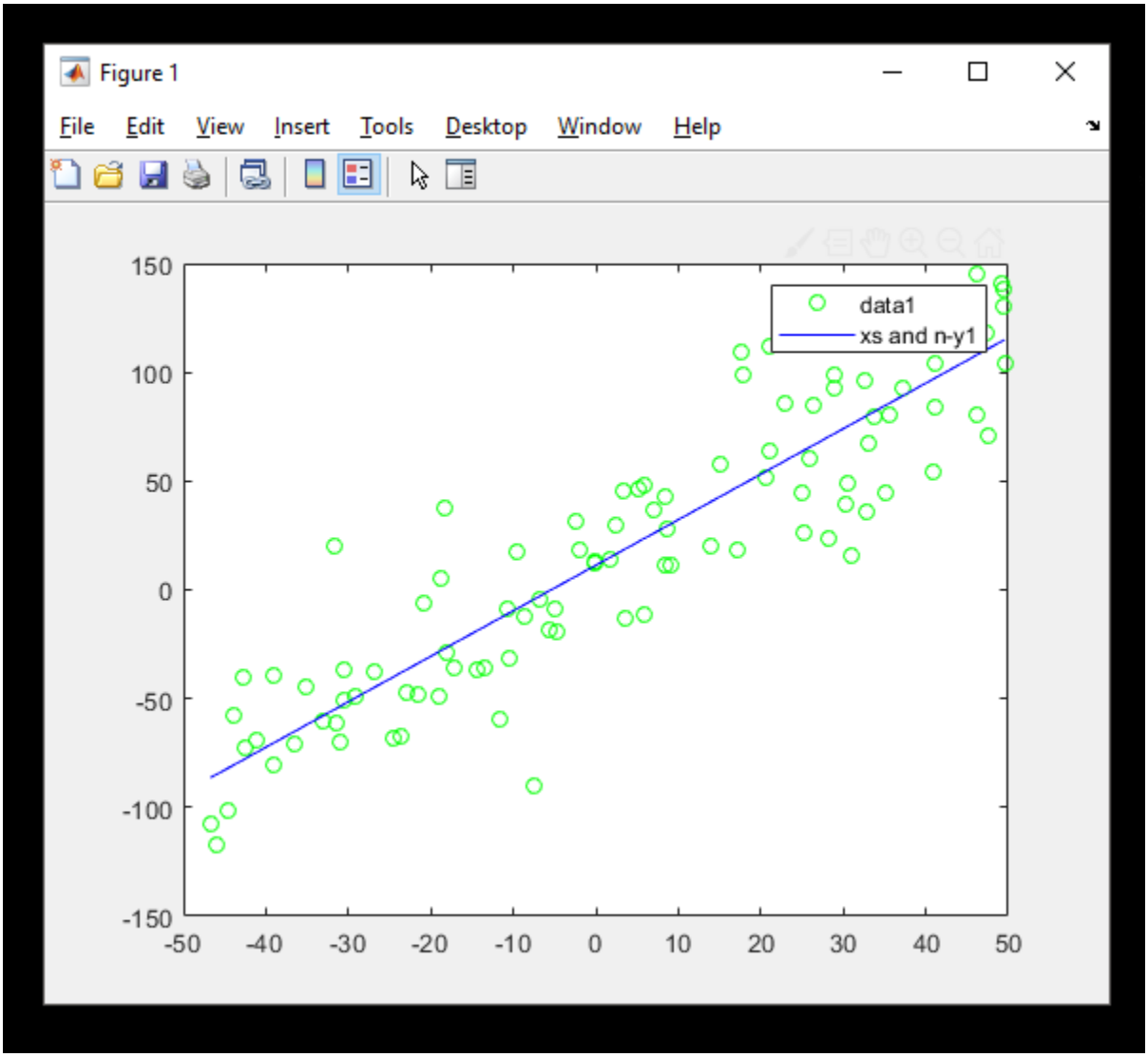


Figure 1
File Edit View Insert Tools Desktop Window Help
data1
xs and n-y1
150
100
50
0
-50
-100
-150
-50 -40 -30 -20 -10 0 10 20 30 40 50

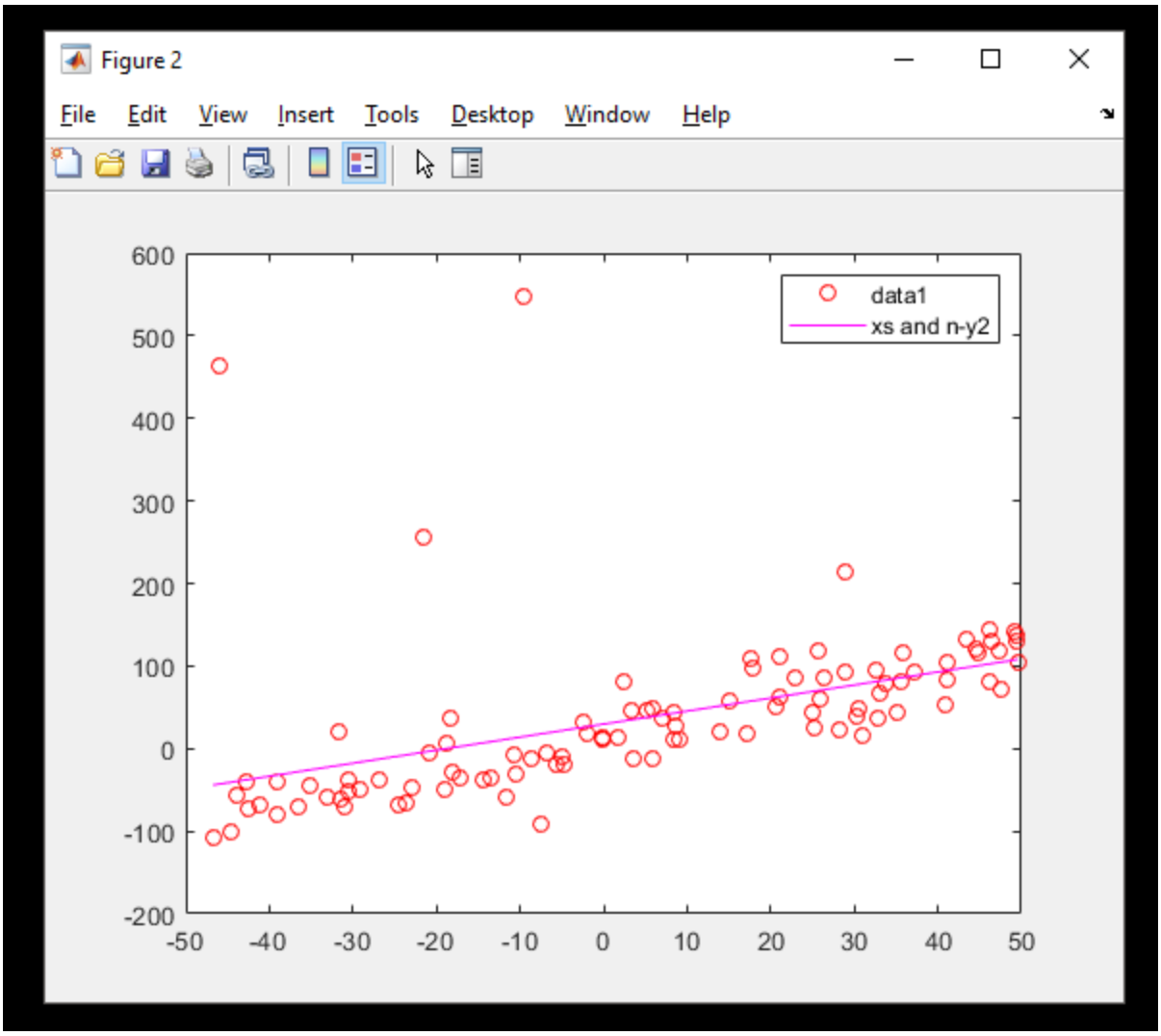


Figure 2
File Edit View Insert Tools Desktop Window Help
data1
xs and n-y2
600
500
400
300
200
100
0
-100
-200
-50 -40 -30 -20 -10 0 10 20 30 40 50

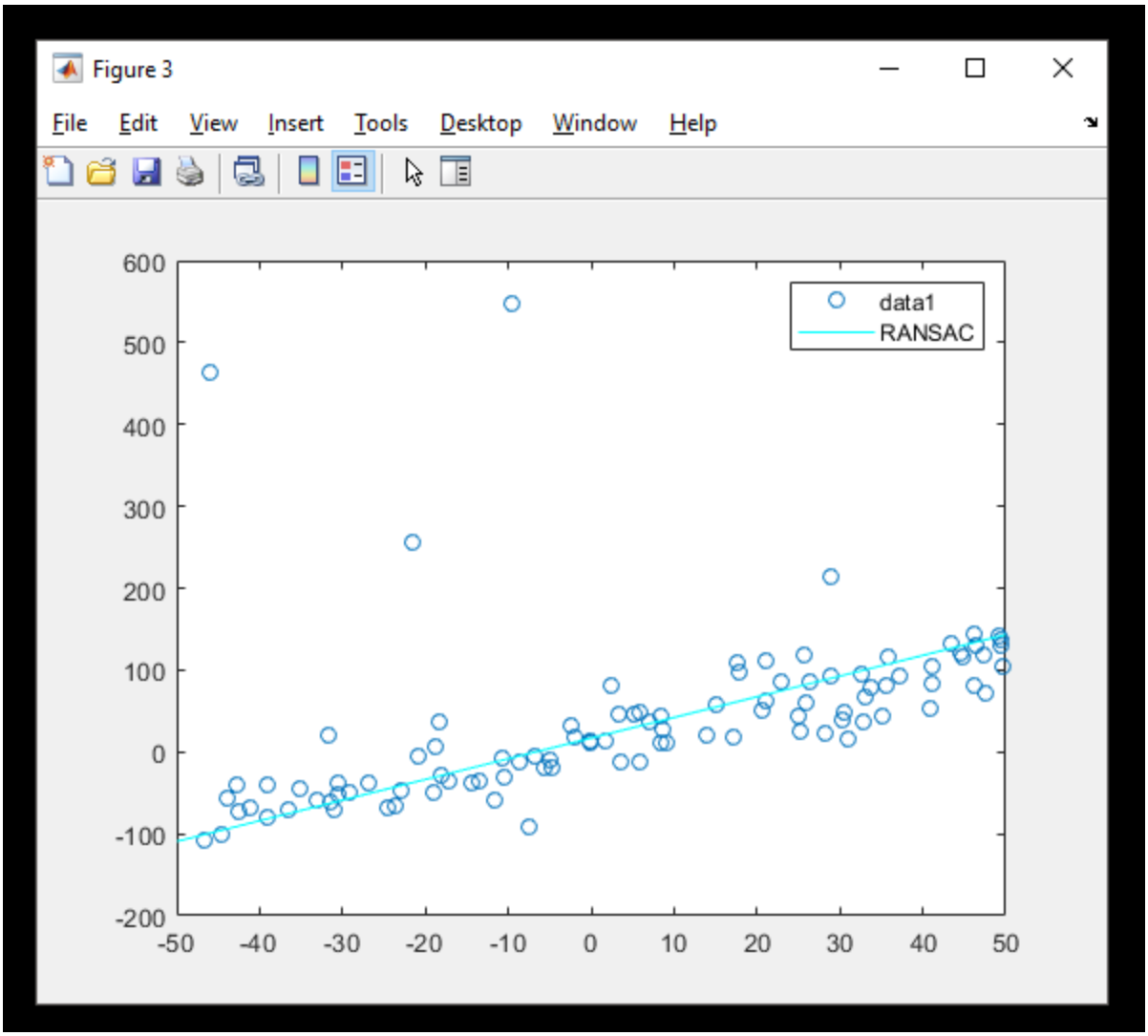


Figure 3
File Edit View Insert Tools Desktop Window Help
data1
RANSAC
600
500
400
300
200
100
0
-100
-200
-50 -40 -30 -20 -10 0 10 20 30 40 50

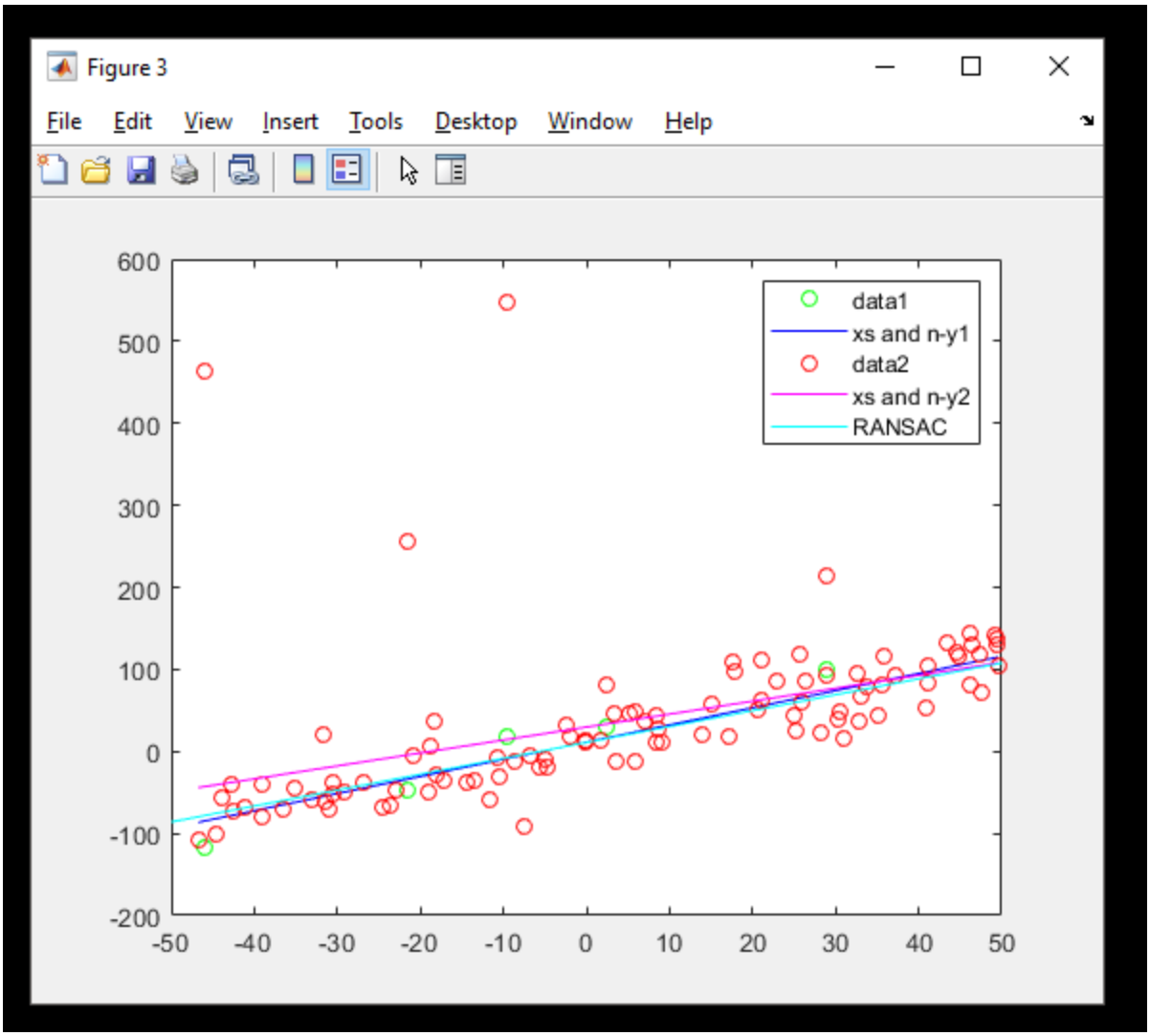


Figure 3
File Edit View Insert Tools Desktop Window Help
600
500
400
300
200
100
0
-100
-200
-50 -40 -30 -20 -10 0 10 20 30 40 50
data1
xs and n-y1
data2
xs and n-y2
RANSAC