



SCHOOL OF ENGINEERING AND NATURAL SCIENCES

Computer Science and Engineering

Computer Vision
Problem Set

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PROBLEM

Corners are tried to be found for every image, but the function found 10 of them. Two of the images are given below.



Figure 1: Input image 1



Figure 2: Corners found 1

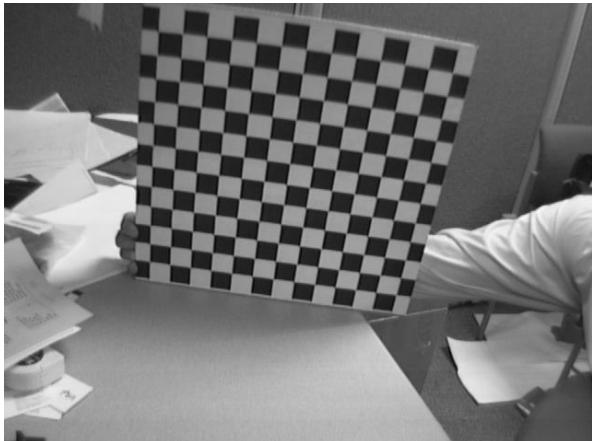


Figure 3: Input image 2

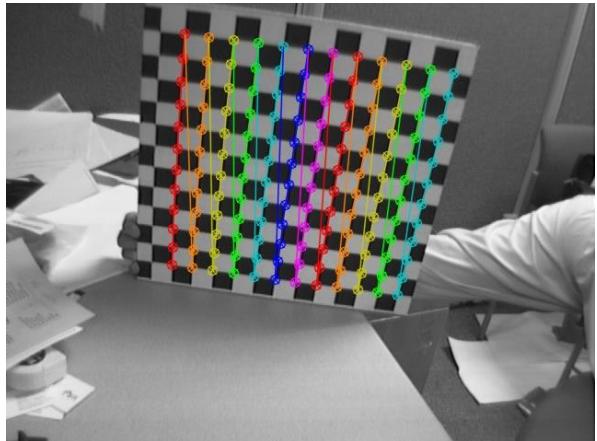


Figure 4: Corners found 2

- (a) Distortion parameters are estimated, and the images are undistorted.

```
-----  
---- Distortion Coefficients ----  
[[-2.47495930e-01  7.03320949e-02 -1.94383447e-04  
-2.82181439e-04  
 1.09232915e-01]]
```

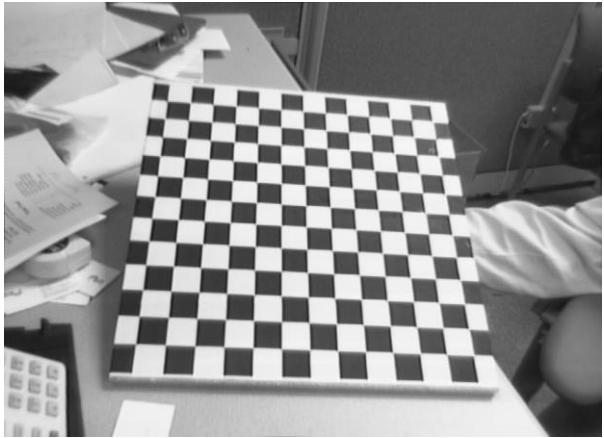


Figure 5: Undistorted image 1

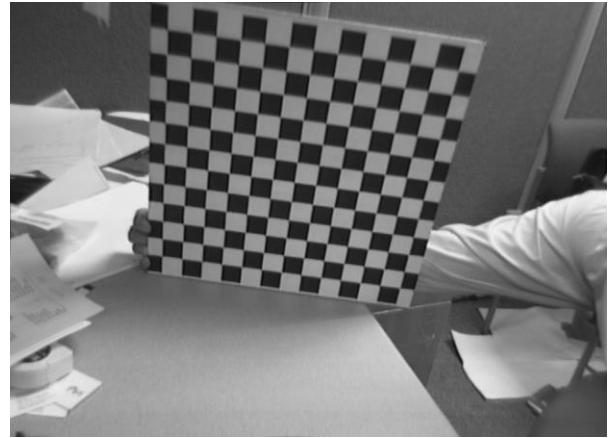


Figure 6: Undistorted image 2

(b) Intrinsic matrix is estimated.

```
----- Intrinsic Matrix -----
[[659.03841658  0.          302.37834068]
 [ 0.           659.79518135 243.69565429]
 [ 0.           0.          1.          ]]
```

(c) Projection matrix is estimated for each image.

```
----- Projection Matrix -----
[[[-6.25700311e+01,  6.58169054e+02,  2.97762964e+02,
   -5.41541534e+00],
 [-6.89234709e+02,  9.36674787e+01,  -1.04399100e+02,
   1.77378308e+00],
 [-4.83731299e-01,  1.75587597e-02,  8.75040411e-01,
   2.88813307e+01]], array([[ 6.94535079e+02,
 4.98439371e+01,  2.02239712e+02,
   -4.40331639e+00],
 [ 7.73984726e+01,  6.95288786e+02,  -7.28027006e+01,
   -4.81930747e+00],
 [ 1.44872107e-01,  4.27788934e-01,  8.92193197e-01,
   1.82063387e+01]], array([[ 6.96740298e+02,
 5.07940015e+01,  1.94260705e+02,
   -4.10234317e+00],
 [ 7.00500162e+01,  6.97750169e+02,  -5.43594481e+01,
   -4.60151187e+00],
 [ 1.53095002e-01,  4.04145025e-01,  9.01791949e-01,
   1.64029218e+01]], array([[ 7.08519339e+02,
 1.00270878e+01,  1.53831398e+02,
   -6.62139363e+00],
 [ 7.83583451e+01,  6.95181333e+02,  7.28020457e+01,
   -4.51362859e+00],
 [ 2.17436566e-01,  2.26615960e-01,  9.49403258e-01,
   1.58789894e+01]], array([[ 6.42170054e+02,
 -1.89552627e+02,  2.78301490e+02,
   -5.06969722e-01],
 [ 1.36439288e+02,  5.92547685e+02,  3.53537572e+02,
   -5.71947357e+00],
 [-7.35557162e-03,  -1.74507293e-01,  9.84628407e-01,
   2.32496955e+01]], array([[ 6.86368134e+02,
 -1.49953635e+02,  1.79379451e+02,
   -5.14139238e+00]]]
```

```

[ 6.31384705e+01,  4.44888967e+02,  5.41114215e+02,
-5.35754303e+00],
[ 1.06207011e-01, -5.07402773e-01,  8.55138876e-01,
 2.53173792e+01]]), array([[ 6.40265318e+02,
-2.56885555e+02,  2.23236263e+02,
-4.14702185e+00],
[ 1.02015534e+02,  4.37632775e+02,  5.41098548e+02,
-5.86573930e+00],
[-3.07997070e-02, -5.03531351e-01,  8.63427794e-01,
 2.59124456e+01]]], array([[-3.30475480e+02,
-4.63631502e+02,  4.48994525e+02,
 7.79103692e+00],
[ 3.99291414e+02,  1.07463387e+02,  5.68977363e+02,
-5.24602392e+00],
[-5.37651411e-01,  4.32172367e-01,  7.23987573e-01,
 2.12578041e+01]]], array([[ 6.89604083e+02,
1.09526845e+02,  1.95484972e+02,
-4.94750429e+00],
[ 8.04012094e+01,  6.45233991e+02, -2.68190222e+02,
-2.68212968e+00],
[ 1.24339614e-01,  6.67385353e-01,  7.34259117e-01,
1.48719271e+01]]], array([[ 5.42369816e+01,
-6.94493188e+02, -2.01250732e+02,
 5.91300055e+00],
[ 6.82504935e+02, -3.54730383e+00, -1.69975539e+02,
-4.91568470e+00],
[ 5.12021524e-01, -5.79216694e-01,  6.34304328e-01,
2.11005085e+01]]])

```

(d) Essential matrix between the first image and each of the remaining images are estimated.

```

----- Essential Matrix -----
[[array([[24.15183517, -3.88167248, 15.45635935],
       [ 1.04840888, 28.70564453, 6.19231746],
       [ 4.46421843, -2.49082898, 2.5178472 ]]),
array([[ -1.85971554, -18.37071787,  3.70872953],
       [ 18.61470068, -0.312827 ,  2.06277004],
       [ 4.47761912, -4.52587937,  1.44300472]]),
array([[ -1.51844093, -16.75770171,  2.66524405],
       [ 16.81715384, -0.11941177,  1.74761001],
       [ 4.33795686, -4.22457161,  1.15683011]]),
array([[ -1.59199608, -16.42438937, -0.46918067],
       [ 16.92677805,  0.09108425,  3.07588158],
       [ 4.14761638, -6.82292959,  0.67868029]]),
array([[ -4.82890747, -21.38049938, -9.63413807],
       [ 22.72934535, -4.91401397, -0.18623699],
       [ 5.48616993, -1.67506877, -0.25589126]]),
array([[ -1.99859085, -19.09737354, -17.34845577],
       [ 25.67961302, -2.47530184,  1.354239 ],
       [ 5.0283282 , -4.40206018, -3.236505 ]]),
array([[ -4.12061789, -19.05295826, -18.05178735],
       [ 25.41276755, -6.20200129,  2.09261917],
       [ 5.0931656 , -4.45316349, -2.41530263]]),
array([[-14.26556806, -2.33629135, -16.44537364],
       [-1.22692817, -22.5370432 ,  1.78068075],
       [ 4.92558273, -4.70545945,  6.46670776]]),
array([[-1.46276407, -12.6678123 ,  8.10893877],
       [ 15.32841441,  1.21958172,  3.03386655],
       [ 2.27783282, -3.99430275,  3.24478681]]),
array([[-20.35328088, -1.55342438,  7.26128399],
       [-6.24809665, -13.2031992 , -16.33498863],
       [ 4.24801554, -2.64056978, -5.84031564]])]

```

(e) Rotation and translation between the reference image and each of the remaining images are estimated.

```
----- Rotation 1 -----
[[ 0.07539721 -0.93291862 -0.35210526]
 [ 0.79965799 -0.15438035  0.58027046]
 [-0.59570325 -0.32531455  0.73437598]]
```



```
----- Rotation 2 -----
[[ 0.12700297  0.9906246   0.05033044]
 [-0.86595281  0.13547914 -0.48142614]
 [-0.4837313   0.01755876  0.87504041]]
```



```
----- Translation -----
[[ 0.18395913]
 [-0.06025458]
 [-0.98108533]]
```

(f) Epipolar lines are drawn for 2 images. The images are shown below.

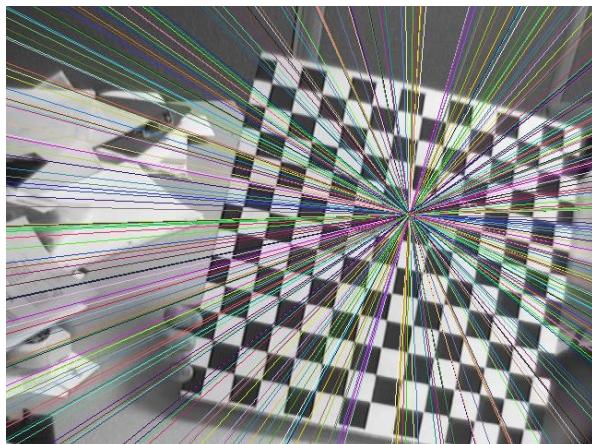


Figure 7: Epipolar lines 1

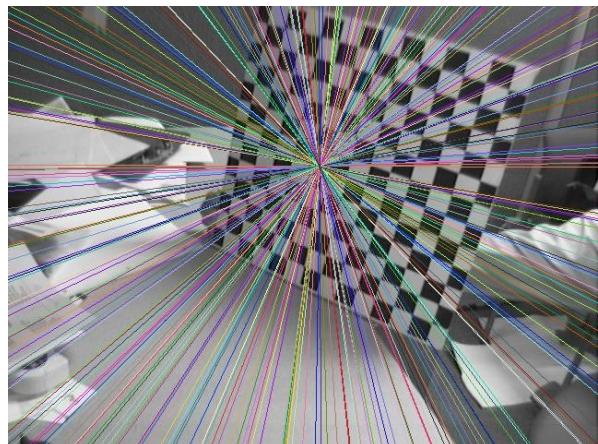


Figure 8: Epipolar Lines 2