Computer Vision Home Work 1 - AutoCalib

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***Abstract*—In this work, we estimate the camera calibration matrix of a camera and also estimate its radial distortion parameters. Images of a chess checkerboard pattern are used to estimate the calibration matrix. The values are further optimized to minimize error.**

I. Introduction

We follow the method detailed by Zhengyou Zhang to estimate the parameters of camera calibration matrix. This method is robust and quite efficient. The data utilized are images taken using a Google Pixel XL camera with focus lock enabled. The subject of the images is the checkerboard pattern of a chessboard. The vertices of the pattern serve as our calibration points basis.

A. Data Preparation and Solving for Calibration Matrix

Using cv2.findChessboardCorners, the vertices of the chessboard are found for all greyscaled images in our dataset. Using the method discussed in the paper by Zhangyou Zhang, initial rotation (R) and translation (t) matrices calculated. We can also initially assume that the camera has minimal distortion and we can assume that

$$\text{k} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

After calculation, the initial K matrix is given by: K =

$$\begin{bmatrix} 2.46608379e+3 & -1.14440530e+0 & 7.62413507e+2 \\ 0.00000000e+0 & 2.44647026e+3 & 1.34707151e+3 \\ 0.00000000e+0 & 0.00000000e+0 & 1.00000000e+0 \end{bmatrix}$$

This is an approximate solution which can be further refined/fine-tuned.

B. Non-linear Geometric Error Minimization

Now that we have the initial estimates of K, R, t, and k matrices, we can try to minimize the geometric error. We can use scipy.optimize to minimize using the loss function as given below:

$$\sum_{i=1}^{N}\sum_{j=1}^{M} ||x_{i,j} - \hat{x}_{i,j}\left(K, R_i, t_i, X_j, k\right)||$$

After optimizing, the optimized K matrix is given by:

$$\text{K} = \begin{bmatrix} 2.46607878e+3 & -1.14709634e+0 & 7.62421730e+2 \\ 0.00000000e+0 & 2.44645816e+3 & 1.34708906e+3 \\ 0.00000000e+0 & 0.00000000e+0 & 1.00000000e+0 \end{bmatrix}$$

And the optimized distortion matrix k is given by:

$$\text{k} = \begin{bmatrix} 0.01430135 \\ -0.14682553 \end{bmatrix}$$

The reprojection error after optimizing is given as:

C. Output

The checkerboard image after rectification using the matrices calculated above is shown in Fig. 1

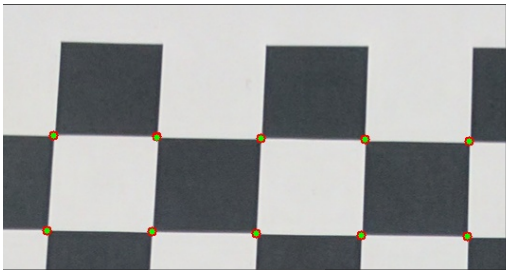

Fig. 1: Green dot is Reprojected dot, Red circle is detected corner

II. All Undistorted Output Images with reprojected corners

All the output images are shown below in figures 2 - 14.

III. Conclusion

Here in this work we can see the calibrated camera matrix, the optimized matrix, and the results of the calibration in the images.

Acknowledgment

The authors would like to thank the professor for the instructions and knowledge imparted via the course.

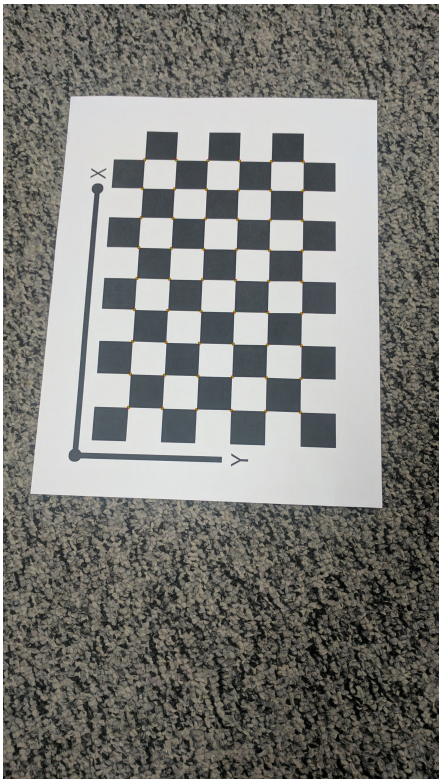

Fig. 2: Image 1

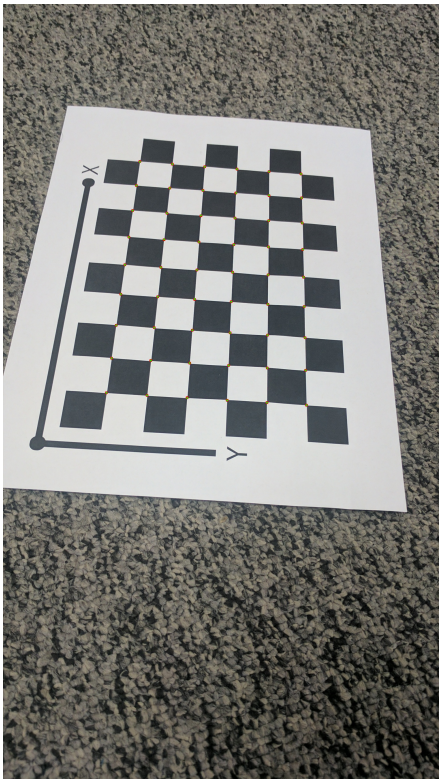

Fig. 4: Image 3

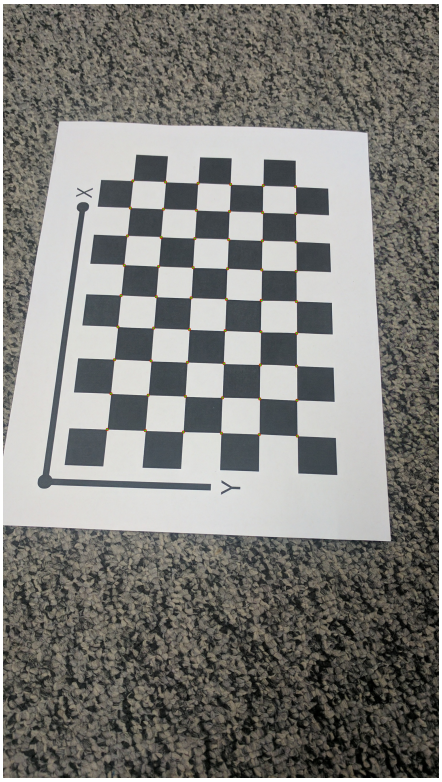

Fig. 3: Image 2

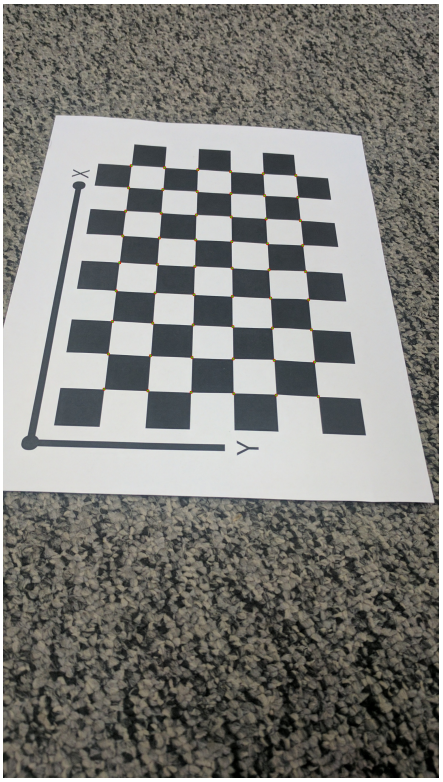

Fig. 5: Image 4

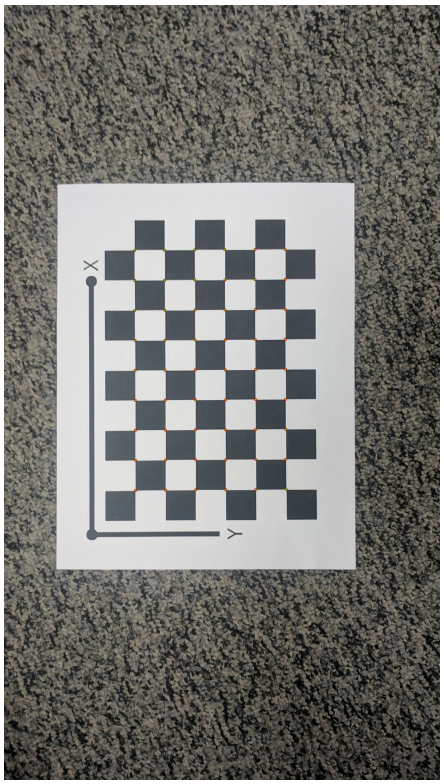

Fig. 6: Image 5

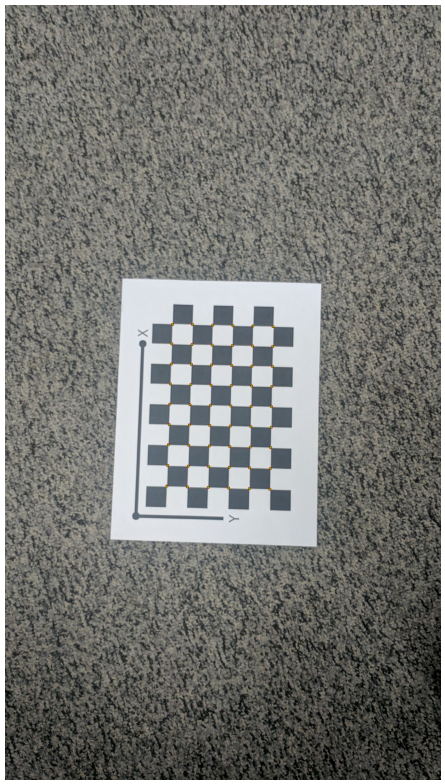

Fig. 8: Image 7

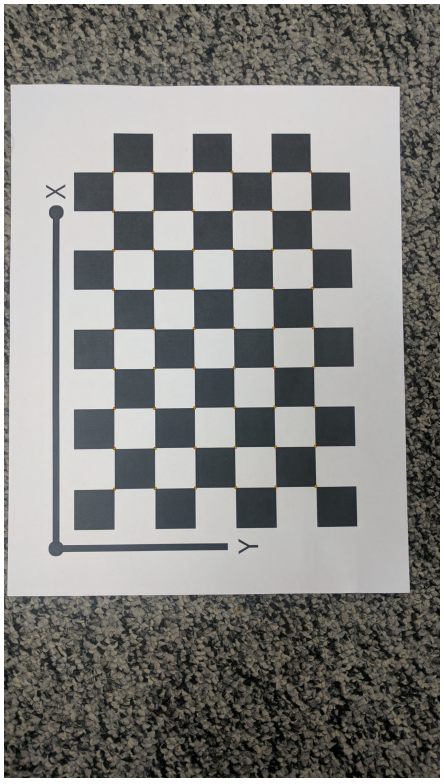

Fig. 7: Image 6

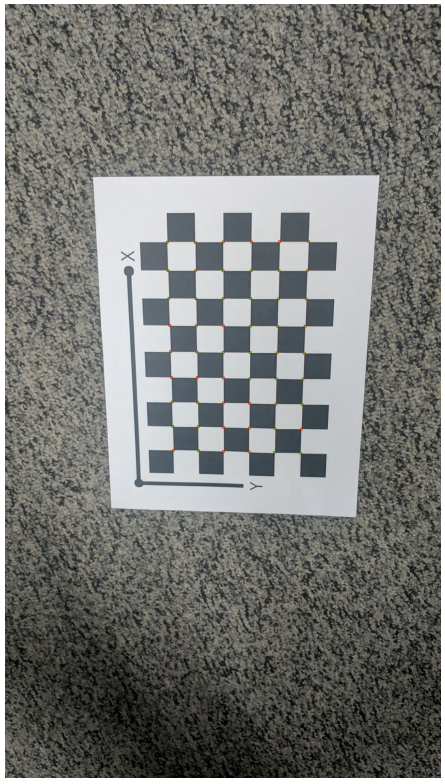

Fig. 9: Image 8

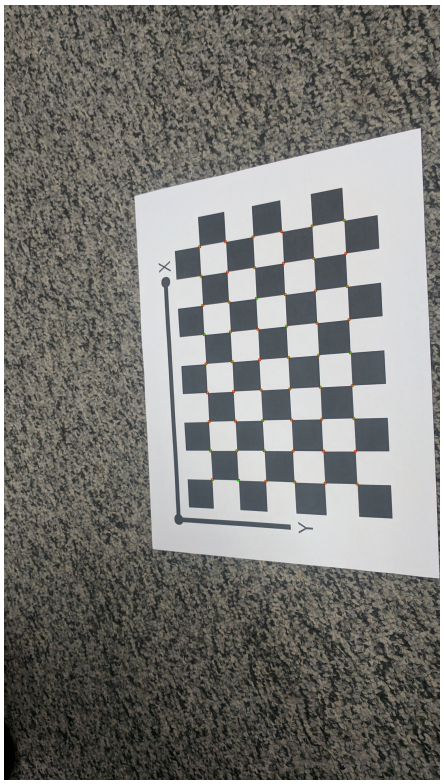

Fig. 10: Image 9

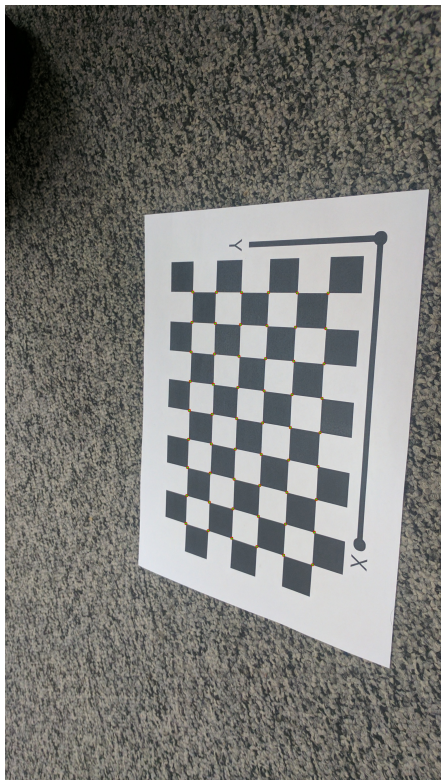

Fig. 12: Image 11

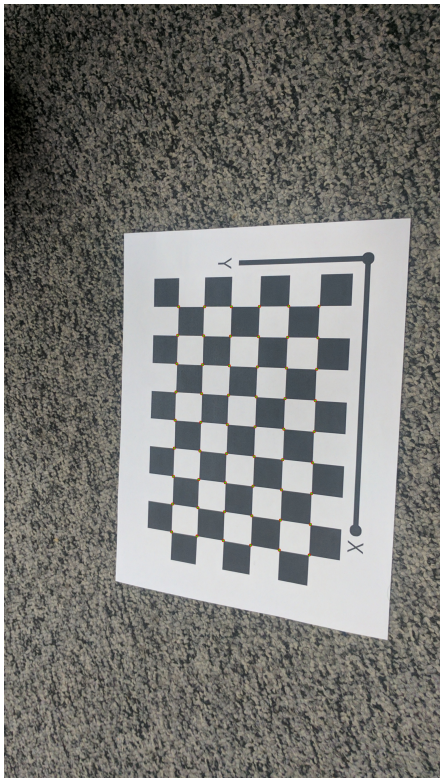

Fig. 11: Image 10

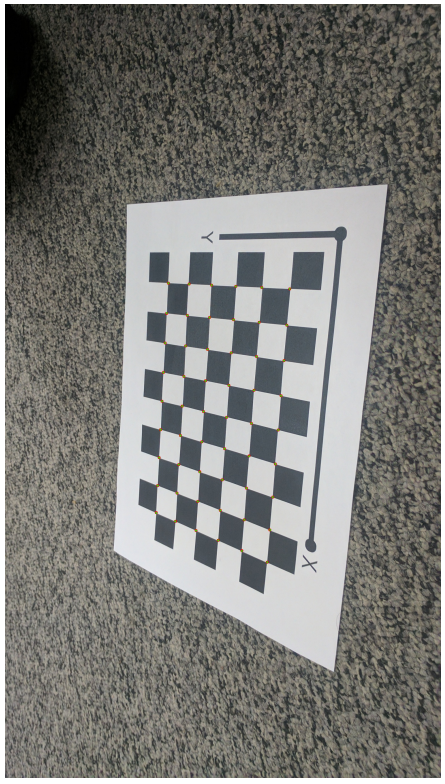

Fig. 13: Image 12

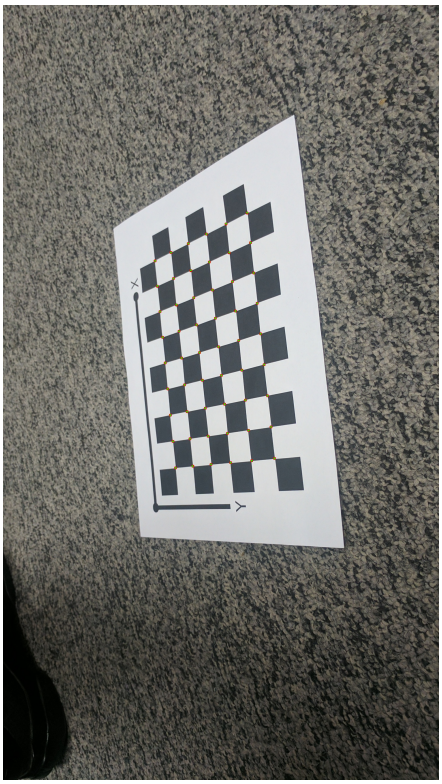

Fig. 14: Image 13