CMSC733: Homework 1, AutoCalib!

Naveen, Mangla
nmangla@umd.edu

I. Introduction

Camera Calibration is one of the most time consuming but significant process for any computer vision research involving 3D geometry, of which robotics research is a very prime example. An automatic way to perform efficient and robust camera calibration was provided by Zhengyou Zhang of Microsoft?. In this report is summarized the implementation of Zhang's technique for calibration.

II. Data

For the purpose of calibration, total of 13 images of checker-box of known dimensions were given clicked from different angle and positions.

III. Calibration Approach

The Approach for calibration the camera required following steps.

1) Find all the checker box points $(9 \times 6 = 54)$
2) Find the 4 corner points of checker-board (Here we are ignoring the boundary boxes)
3) Calculate Holography Matrix for every image.(Warld to image coordinates)
4) Compute the Intrinsic parameters by solving for B = AT A, where A is the intrinsic camera matrix. The initial intrinsic camera matrix computed for this project is

$$K_{intial} = \begin{pmatrix} 2034.7510 & 0.4928 & 772.7039 \\ 0 & 2017.9046 & 1360.9098 \\ 0 & 0 & 1 \end{pmatrix}$$

5) This K matrix is used to estimate Matrix R (Rotational) and t (Transitional)
6) From these parameters, we calculated distortion coefficients $k1.k2$ initializing with zero with $[0,0]^T$ and minimizing the error function using **scipy.optiize.leastsquare** function.The following values of the intrinsic camera matrix and distortioin coefficients were obtained

$$K_{optiized} = \begin{pmatrix} 2039.3168 & 0.4539 & 775.0797 \\ 0 & 2026.3194 & 1364.8693 \\ 0 & 0 & 1 \end{pmatrix}$$

$$k1, k2 = 0.01887696, -0.10494365$$

IV. Discussion and results

The newly obtained Intrinsic Matrix is more accurate as it is computed keeping distortion in account, this is achieved by minimizing the euclidean distances between computed and obtained corners. using the intrinsic camera matrix A, extrinsic camera matrix R, t and the distortion coefficients Kc. After optimization there is still some error left because this optimization gives a local minima. This is why a good initial guess is necessary. To evaluate the accuracy of the calibration matrices obtained we compute the re-projection error. To find the average error we calculate the arithmetical mean of the errors calculate for all the calibration images. This value comes out to be **2.3638**
As can be seen in the following image, we can clearly see the difference in the original point and the point once the un-distortion has been performed. The blue circle was the original point and the red circle represents the point after the calibration. These calibration matrices are then used to rectify the images. The output rectified images are shown below:

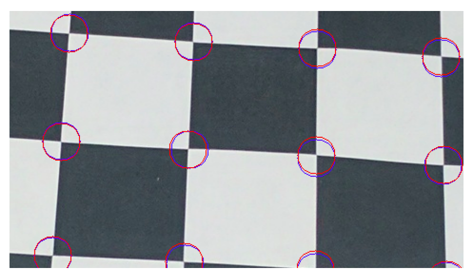

Fig. 1: Corners before (blue) and after(red) Distortion

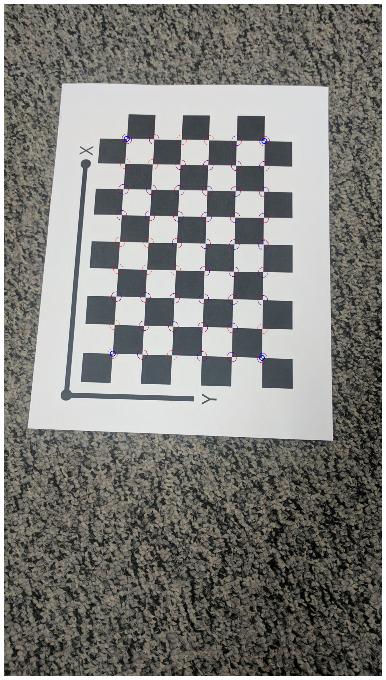

Fig. 2: Rectified Image 1

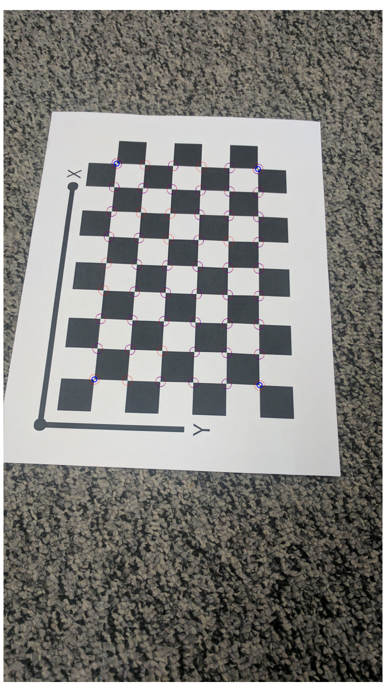

Fig. 3: Rectified Image 2

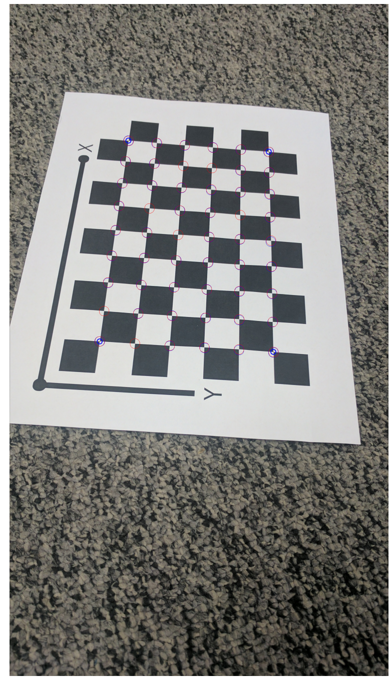

Fig. 4: Rectified Image 3

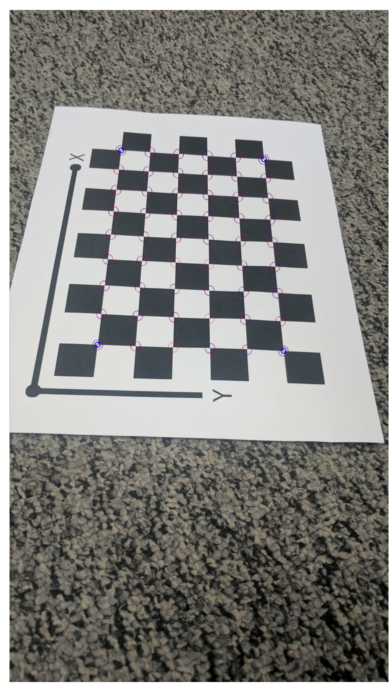

Fig. 5: Rectified Image 4

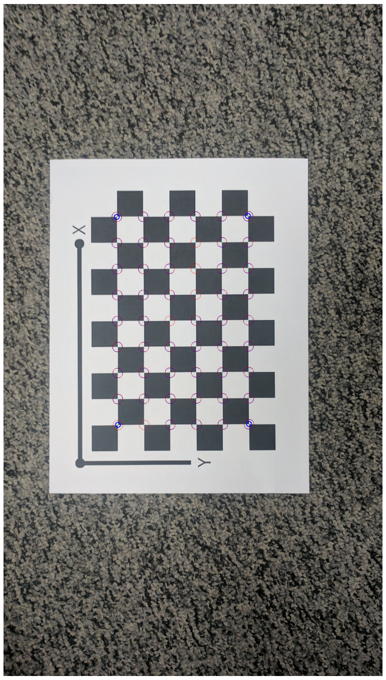

Fig. 6: Rectified Image 5

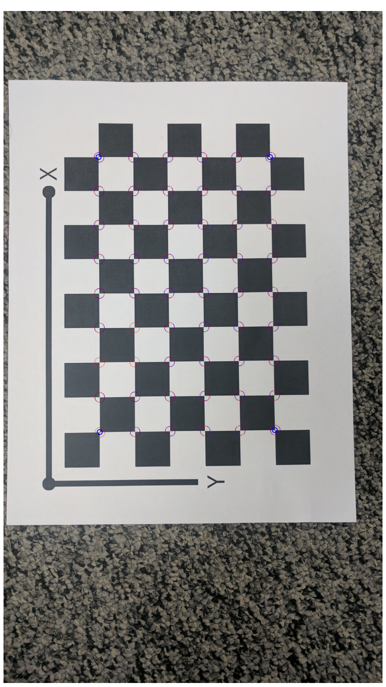

Fig. 7: Rectified Image 6

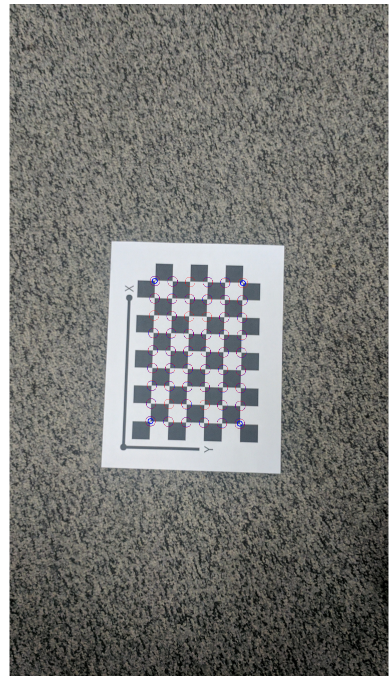

Fig. 8: Rectified Image 7

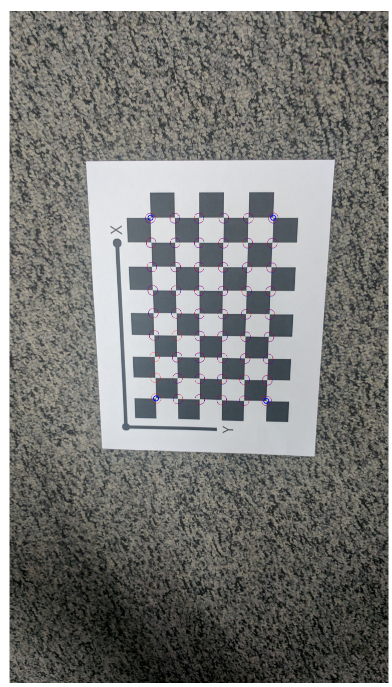

Fig. 9: Rectified Image 8

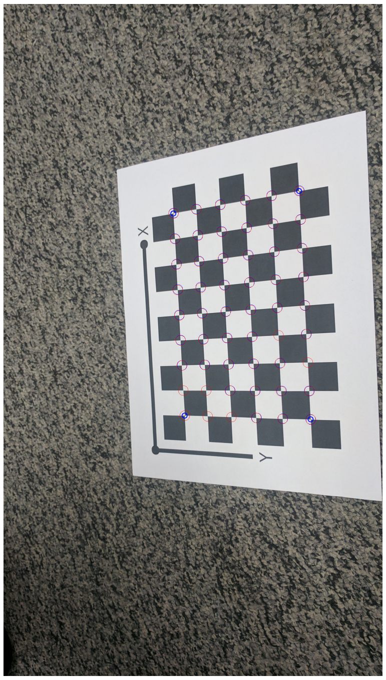

Fig. 10: Rectified Image 9

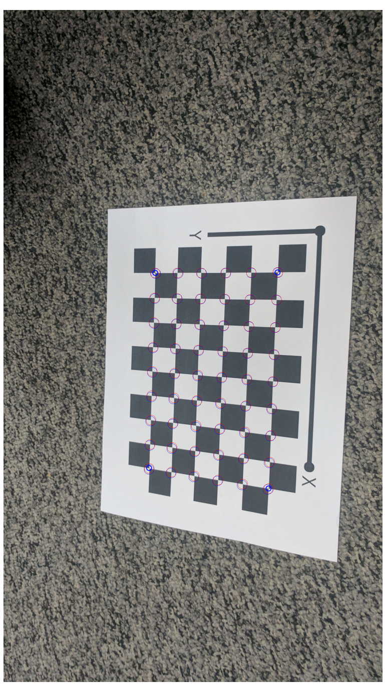

Fig. 11: Rectified Image 10

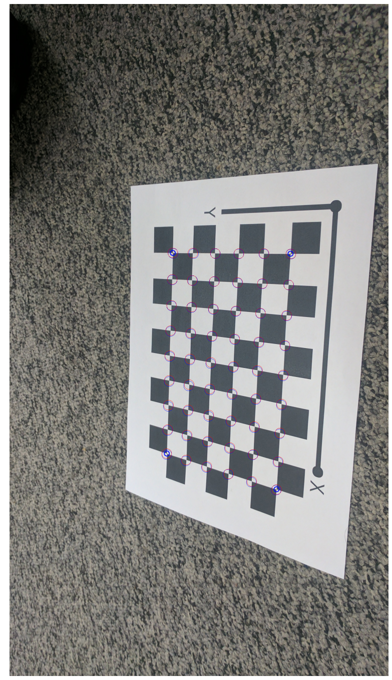

Fig. 12: Rectified Image 11

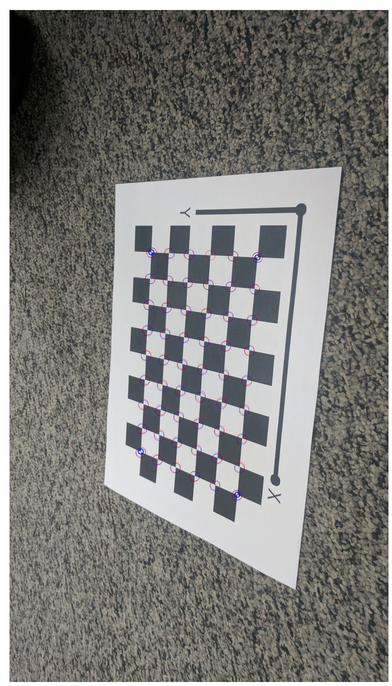

Fig. 13: Rectified Image 12

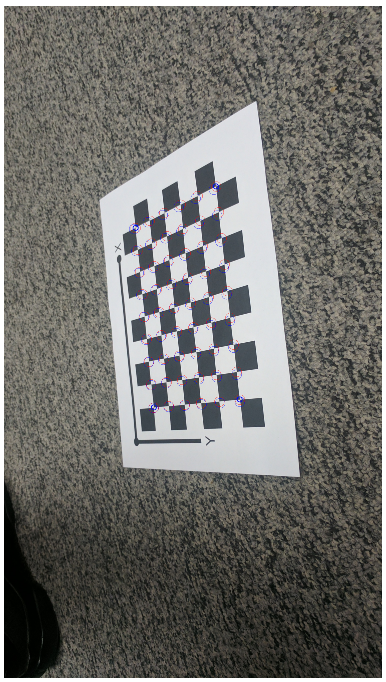

Fig. 14: Rectified Image 13