Homework 1: AutoCalibration

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Using 2 Late day

I. Introduction

Camera Calibration is one of the most significant processes for any computer vision research. An efficient approach robust camera calibration was provided by Zhengyou Zhang of Microsoft[1]. This report is a summarization of the implementation of calibrating a camera.

II. Data

This implementation requires a chessboard images from several views to estimate the camera intrinsic parameters. For this implementation, thirteen images of a checkerboard of known dimensions are used.

III. The Calibration Approach

We first calculate an initial estimate of the intrinsic parameters, which then will be used for optimization of parameters

1) Find all corner points in checkerboard for all the images.
2) Compute the planar homography between the world coordinate points (with the given dimensions of each square size)and the corners found in each image.
3) Compute the Intrinsic parameters by solving for $\mathbf{B} = A^T A$, where A is the intrinsic camera matrix. The initial intrinsic camera matrix obtained by this implementation is,
$$\begin{bmatrix} 2034.7497, & 0, & 772.7044 \\ 0.0000, & 2017.9031, & 1360.9095 \\ 0.0000, & 0.0000, & 1.0000 \end{bmatrix} \tag{1}$$
4) This intrinsic matrix is used to estimate the extrinsic matrices R and t for each of the image.
5) All the above steps are performed assuming there is no distortion of any sorts in the image. Now to calculate the distortion coefficients we use K_c = [0,0] as an initial guess.
6) Once an initial value for each of the parameter A, R, t, K_c is obtained we perform non-linear geometric error minimization to refine them and obtain a better estimate of the camera intrinsic parameters and the distortion coefficients.

$$A = \begin{bmatrix} 2026.3760, & 0.0000, & 772.4453 \\ 0.0000, & 2009.7888, & 1360.318 \\ 0.0000, & 0.0000, & 1 \end{bmatrix} \tag{2}$$

$$K_c = \begin{bmatrix} 0.0957, & -0.46 \end{bmatrix} \tag{3}$$

IV. Discussion and Conclusion

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 **reprojection error** We get a Root-Mean-Squared (RMS) reprojection error value of **1.66**. This is the error obtained between the points obtained using corner metrics on each image and points obtained by projecting the world points to image points using optimized intrinsic parameters. We see that there is a significant change in initial estimate and the parameters obtained by introducing distortion coefficients as well the parameters obtained by reducing the reprojection error for each image. Below are the rectified(undistorted images):

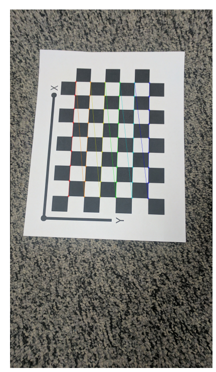

Figure 1: Rectified chessboard image 1

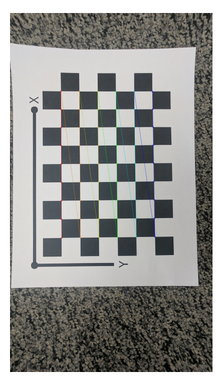

Figure 2: Rectified chessboard image 2

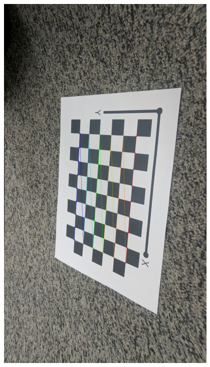

Figure 3: Rectified chessboard image 3

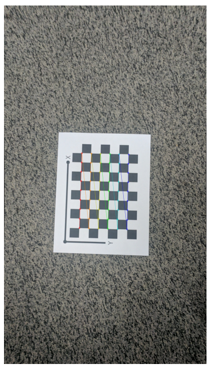

Figure 4: Rectified chessboard image 4

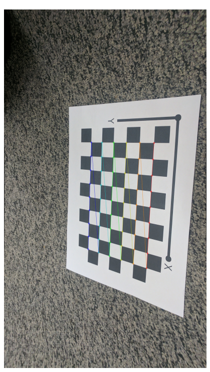

Figure 5: Rectified chessboard image 5

References

[1] Zhengyou Zhang. 2000. A Flexible New Technique for Camera Calibration. IEEE Trans. Pattern Anal. Mach. Intell. 22, 11 (November 2000), 1330-1334. DOI=http://dx.doi.org/10.1109/34.888718

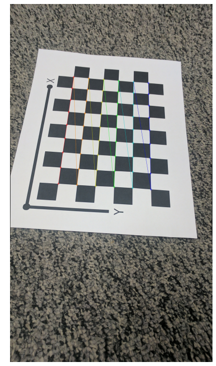

Figure 6: Rectified chessboard image 6

Figure 7: Rectified chessboard image 7

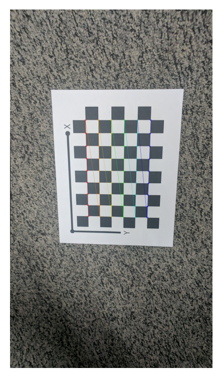

Figure 8: Rectified chessboard image 8

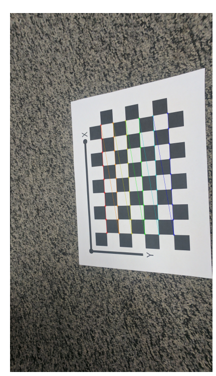

Figure 9: Rectified chessboard image 9

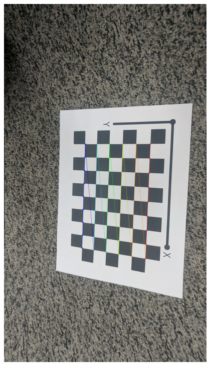

Figure 10: Rectified chessboard image 10

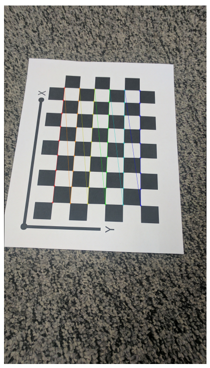

Figure 11: Rectified chessboard image 11

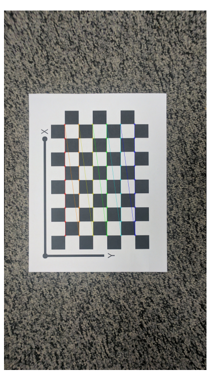

Figure 12: Rectified chessboard image 12

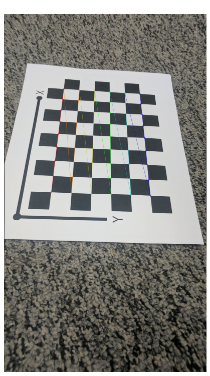

Figure 13: Rectified chessboard image13