HomeWork 1 - AutoCalibration

Sayan Brahma (utilizing 1 late day)
M.Eng Robotics
University of Maryland - College Park
sbrahma@terpmail.umd.edu

I. Introduction

Camera Calibration is one of the most time consuming but very significant process for any computer vision research involving 3D geometry, of which robotics research is a very prime exam- ple. 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 implementation

Zhang's implementation requires a calibration target to estimate the camera intrinsics. For this project 13 image of a checkerboard were provided and are present in the data folder.

III. The Calibration

The first step for the calibration is to find a good initial estimate of the Intrinsic parameters and the distortion coefficients. This is done in the following steps:

1) Find the corner points in the checkerboard for all the given images using the inbuilt openCV *cv2.findChessboardCorners* function.
2) Compute the homographies between the world coordinate points(the checkerboard corners in the original board of which the image.
3) Compute the Intrinsic parameters by solving for

$$B = A^T A$$

where A is the intrinsic camera matrix. The initial intrinsic camera matrix computed for this homework is:

$$\begin{bmatrix} 20343.7949 & 0 & 772.7044 \\ 0.0 & 2017.9031 & 1360.9095 \\ 0.0 & 0.0 & 1.0 \end{bmatrix} \quad (1)$$

4) This intrinsic matrix is used to estimate the extrinsic matrices R and t for each 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

$$Kc = [0, 0]$$

as an initial guess.

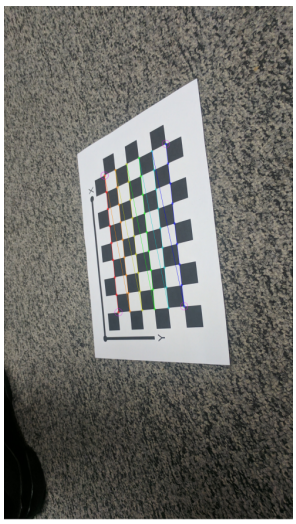
6) Once we have an initial guess for each parame- ter A, R, t, K c we perform Non-linear Geometric Error Minimization to refine them and obtain a better estimate of the camera intrinsic parameters and the distortion coefficients. This was done using *scipy.optimize.leastsquares* funtion of the scipy library. Following are the obtained intrinsic camera matrix(A) and the distortion coefficients (K_c)

$$\begin{bmatrix} 2063.3798 & 0.0 & 763.1675 \\ 0.0 & 2046.5943 & 1381.0201 \\ 0.0 & 0.0 & 1.0 \end{bmatrix} \quad (2)$$

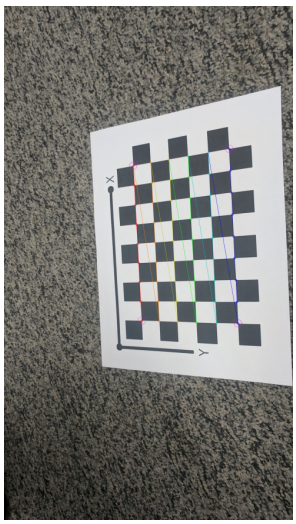
$$\begin{bmatrix} 0.0581 & -0.2572 \end{bmatrix} \quad (3)$$

A. Results

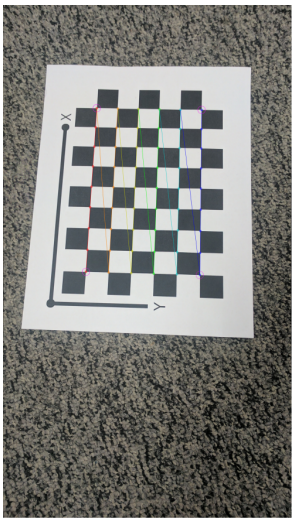
Images of checkerboard after rectification and reprojection of corners on rectified image



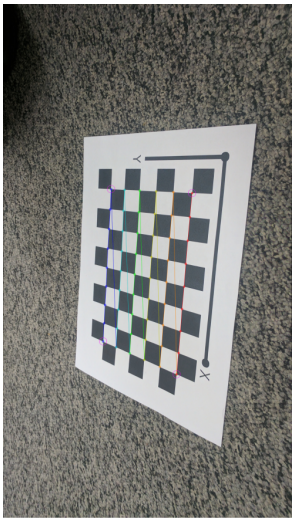
(a) Rectified output image 1



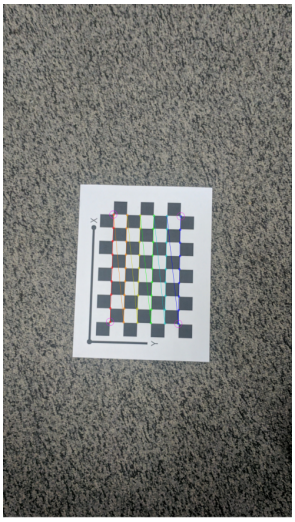
(b) Rectified output image 2



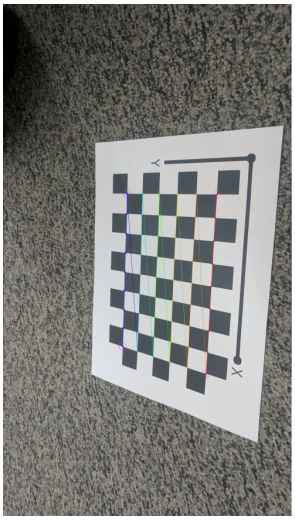
(a) Rectified output image 3



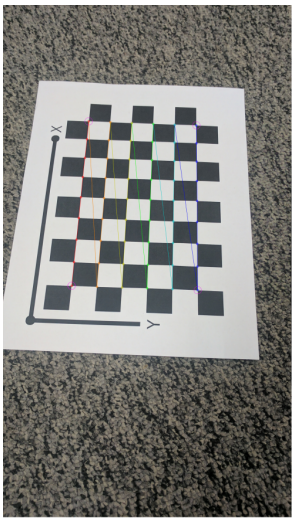
(b) Rectified output image 4



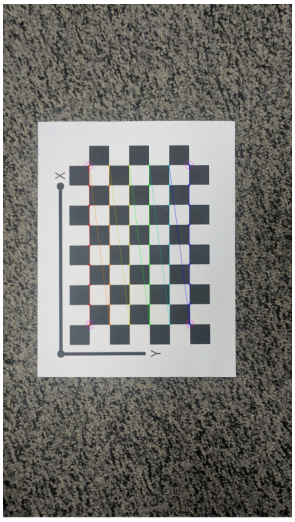
(a) Rectified output image 5



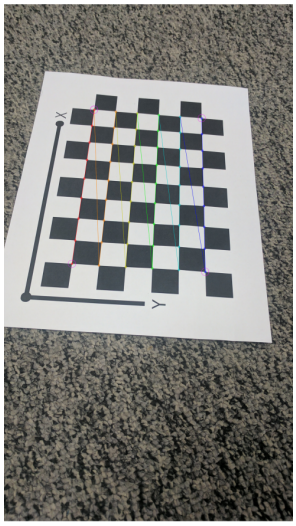
(b) Rectified output image 6



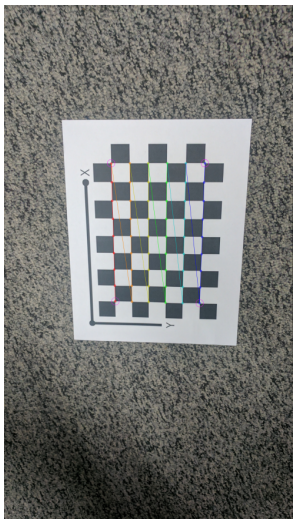
(a) Rectified output image 7



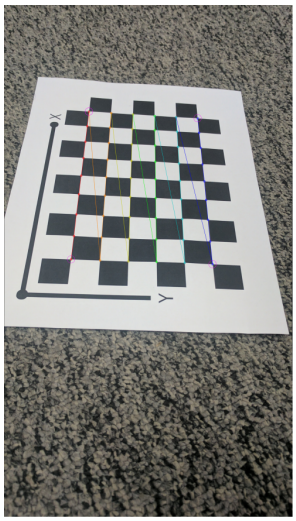
(b) Rectified output image 8



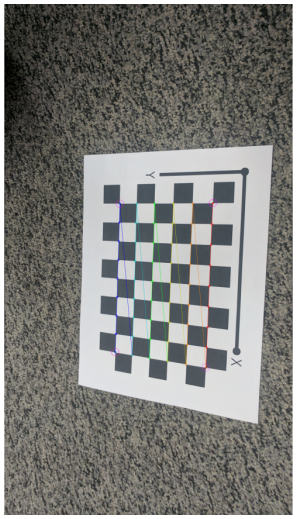
(a) Rectified output image 9



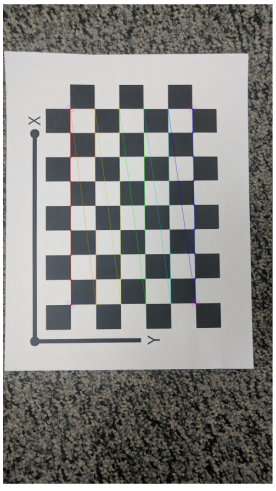
(b) Rectified output image 10



(a) Rectified output image 11



(b) Rectified output image 12



(a) Rectified output image 13

REFERENCES

[1] GitHub - Face Swap *https://github.com/wuhuikai/FaceSwap.*
[2] Website *https://www.learnopencv.com/camera-calibration-using-opencv/*
[3] Microsoft Research Report - A Flexible New Technique for Camera Calibration By *Zhengyou Zhang - December 2, 1998*