AutoCalib

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***Abstract*—In this project, camera calibration is done using a flexible technique from Microsoft. In this work camera's extrinsic and intrinsic parameters are computed. Initially estimated camera parameters are optimized to reduce the error using least squares method.**

I. Introduction

Camera calibration is a parameter estimating method to estimate parameters like the focal length, distortion coefficients and principle point. It is an important and most time consuming part of any computer vision research. Currently , there are many available methods that can work efficiently to estimate the camera parameters. One such method was presented by Microsoft. This works is regarded as the hallmark in the camera calibration.

In this work, I used the multiple photos of checkerboard taken using google pixel XL mobile phone.

II. Initial Parameter Estimation

Initially we estimate the camera parameters and then optimize them using a nonlinear optimizer. Prior to estimating the parameters, image points and world points are computed using opencv library. Opencv's *findChessboardCorners* is used to find the corners in the given checkerboard image, and *cornerSubPix* method is used to improve the accuracy of the corner's location. For each detected corner , the corresponding location with respect to world frame is computed based on number of squares and each square's size.

A. Intrinsic Parameters

After computing the image points and the world points, homography between each pair is computed using *findHomography* method. All the homography matrices are used to find the *V* matrix. Matrix **V** is used to find out solution of **V.b =0**. Solution for it simply translate to simply the eigenvector of *V'V* associated with the smallest eigenvalue (equivalently, the right singular vector of V associated with the smallest singular value). Once the b vector is obtained, the corresponding intrinsic parameters are computed using the equations from Zhang's paper. The initial intrinsic matrix is given below.

$$K = \begin{bmatrix} 2.04 \times 10^3 & -3.17 & 7.60 \times 10^2 \\ 0 & 2.03 \times 10^3 & 1.36 \times 10^3 \\ 0 & 0 & 1 \end{bmatrix}$$

B. Extrinsic Parameters

Once the intrinsic parameters are computed , they are used along with the Homography matrix of each pair to compute extrinsic parameters for each pair. Extrinsic parameters contain rotation and translation matrices.

But for these estimated parameters , the error is huge. This needs to be minimized. Error for each image is given by the following matrix.

$$E = \begin{bmatrix} 38327.234375 \\ 1624277.75 \\ 529229.8125 \\ 70746.5625. \\ 34454.51171875 \\ 34608.01171875 \\ 16160.49804688 \\ 40466.86328125 \\ 83620.875 \\ 64679.9375 \\ 108106.3671875 \\ 32034.06835938 \\ 45144.85546875 \end{bmatrix}$$

C. Distortion Parameters

Radial distortion is assumed to be zero , hence the corresponding parameters are set to zero .

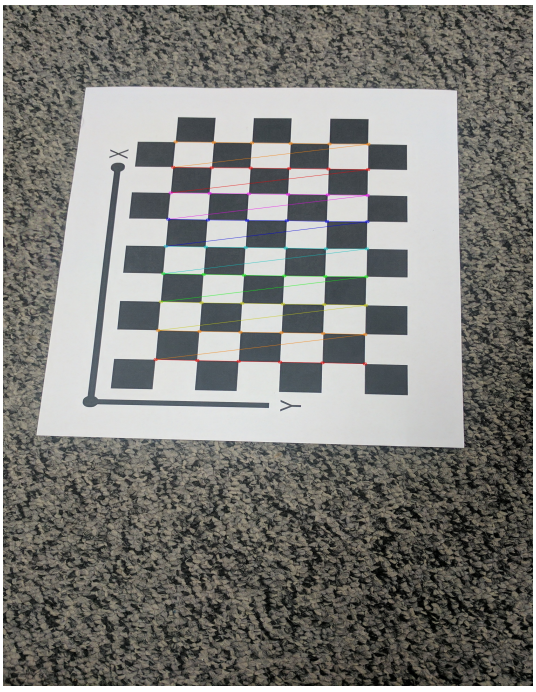
III. Non-linear Geometric Error Minimization

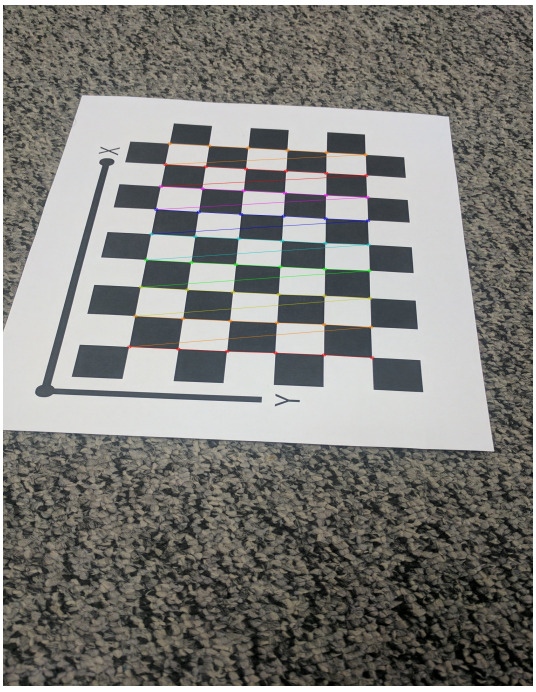
Initially estimated parameters produce a huge error and this need to be compensated. This is considered as an optimization problem and *scipy.optimize* is used to obtain the camera parameters with minimum error.

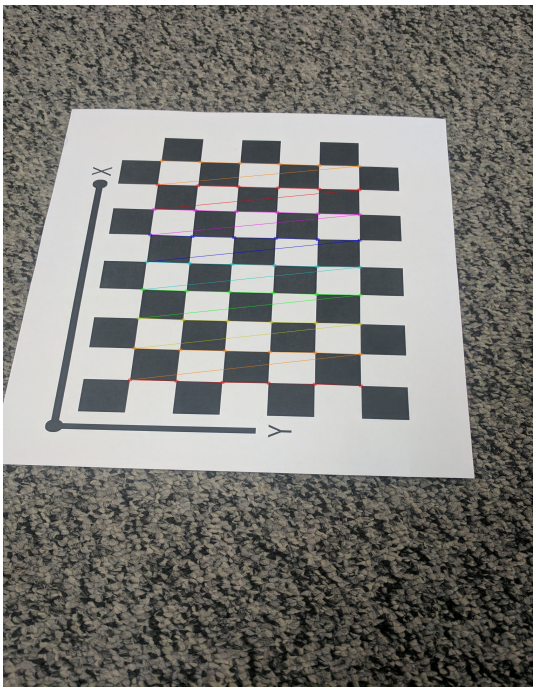
After minimization , the following intrinsic parameters are obtained.

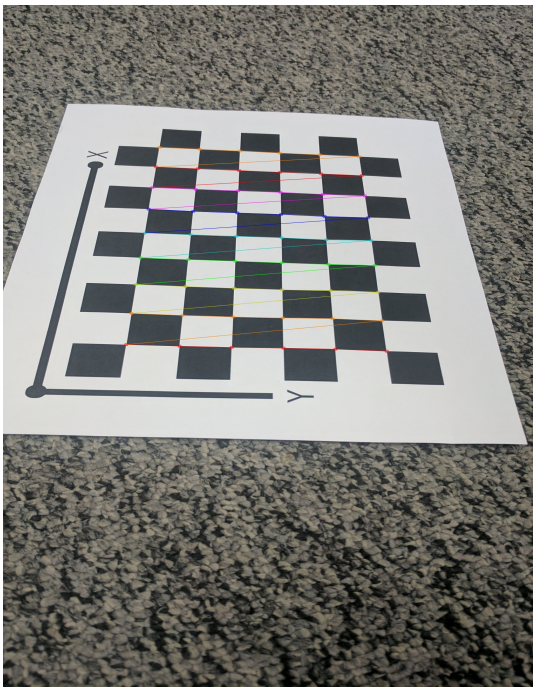
$$K = \begin{bmatrix} 2.03 \times 10^2 & -3.17 & 5.52 \times 10^2 \\ 0 & 2.03 \times 10^3 & 1.36 \times 10^3 \\ 0 & 0 & 1 \end{bmatrix}$$

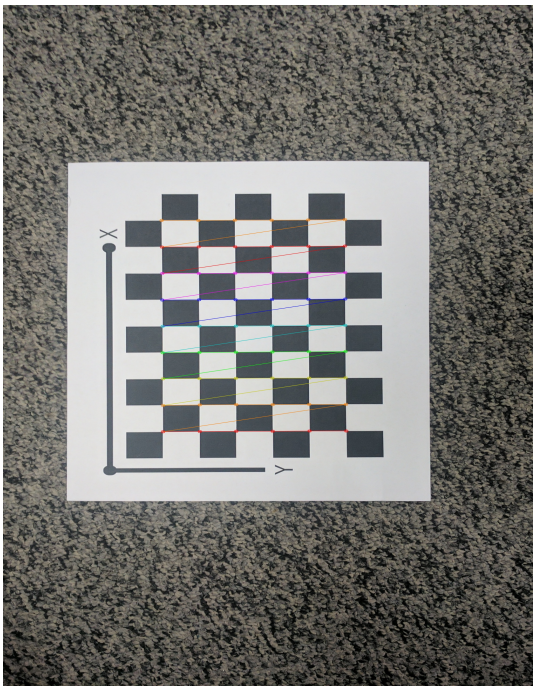
All the results from corner detection are shown by following images.

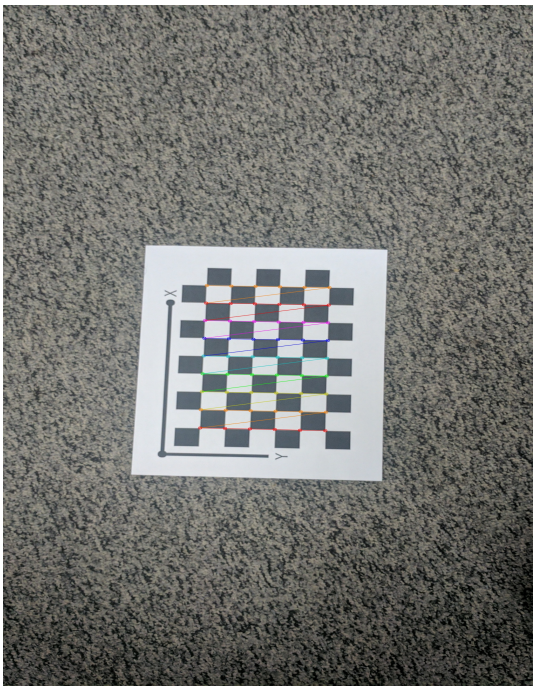

X
Y

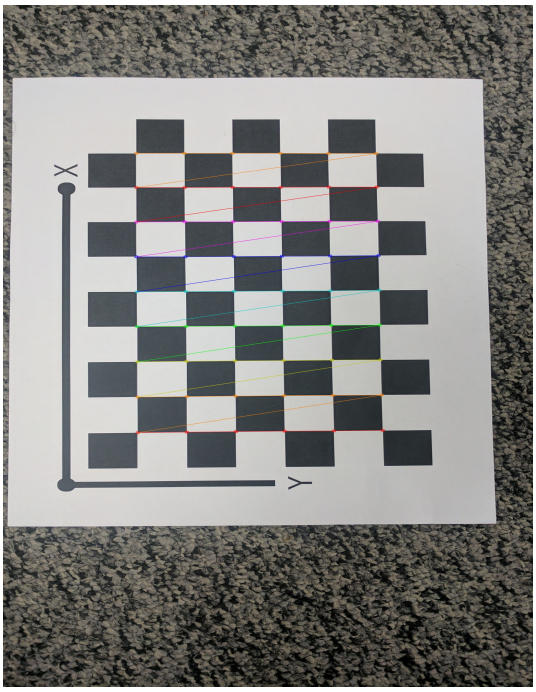

X
Y

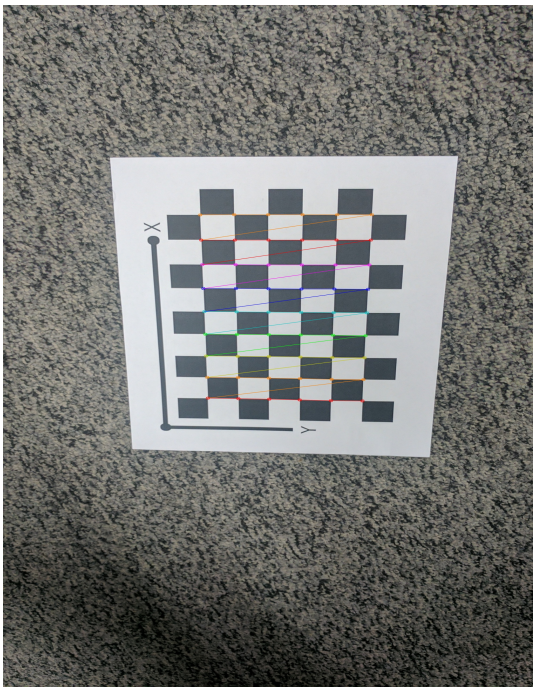

X
Y


X
Y


X
Y


X
Y


X
Y


X
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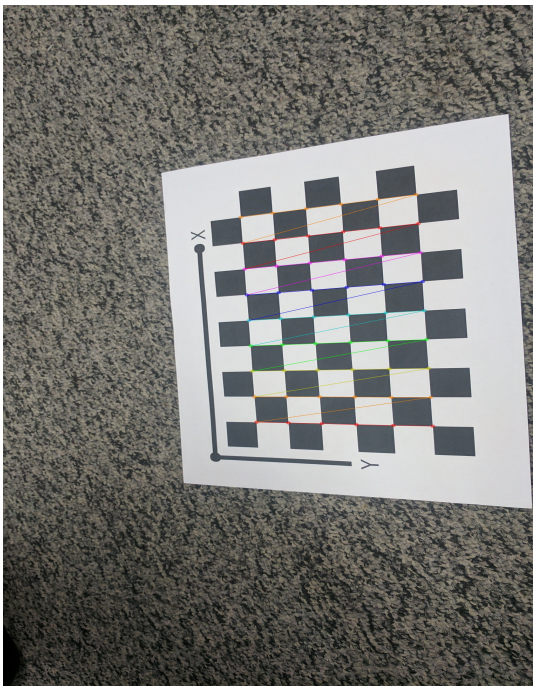
X
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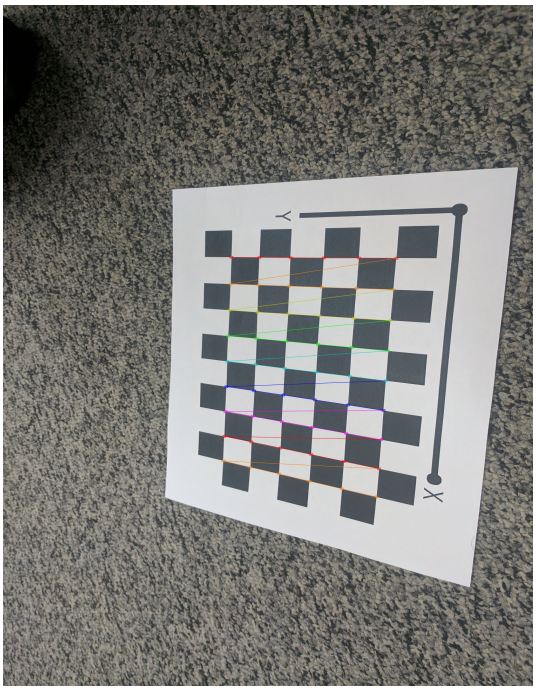
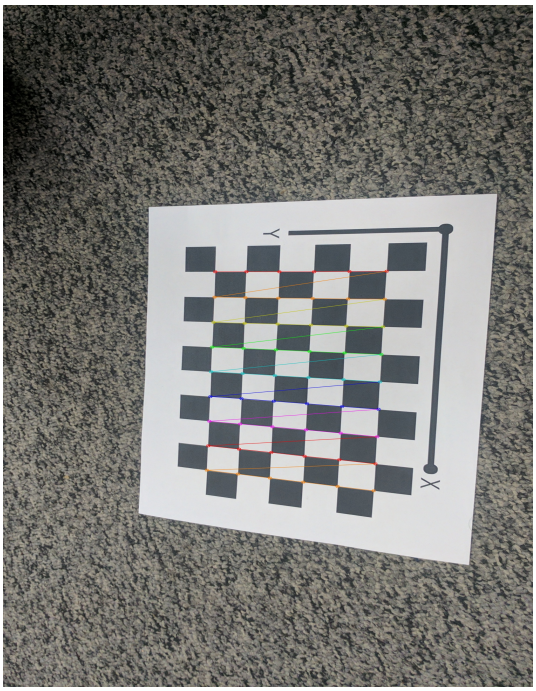

Y
X


Y
X


Y
X

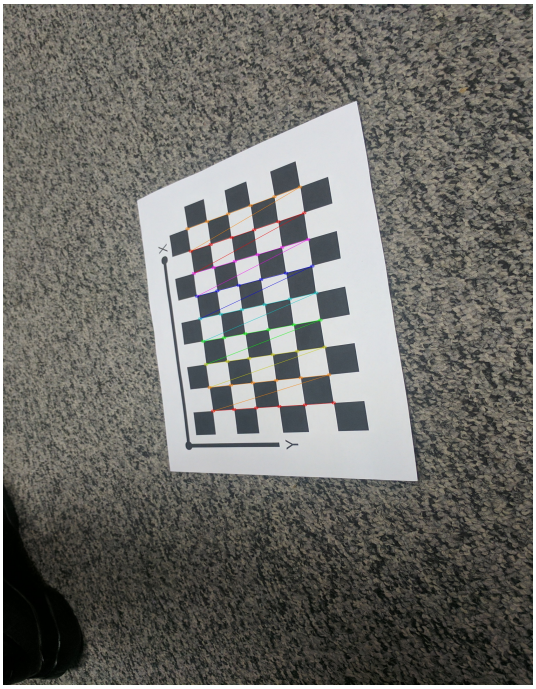


Fig. 1. Corners detection on checkerboard