Homework 1: AutoCalib

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I. Closed-form solution

The main objective of this project was to perform camera calibration by capturing several images of a checkerboard pattern. Zhang's algorithm [1] was then used to estimate camera intrinsic and extrinsic parameters both implicitly as well as through an optimization process. The first step was to identify the checkerboard corners in the image (image coordinates), and to setup the corresponding world coordinate system. Examples are shown in Figs. 1 and 2.

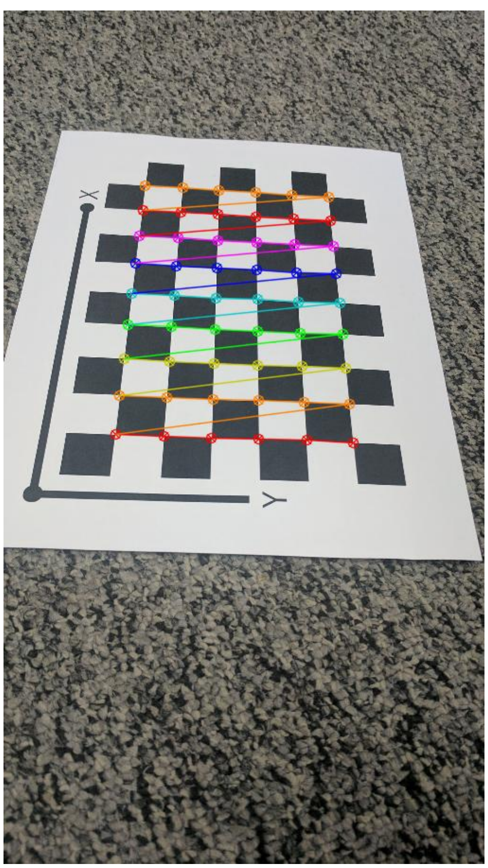

Fig. 1. Detected checkerboard 1

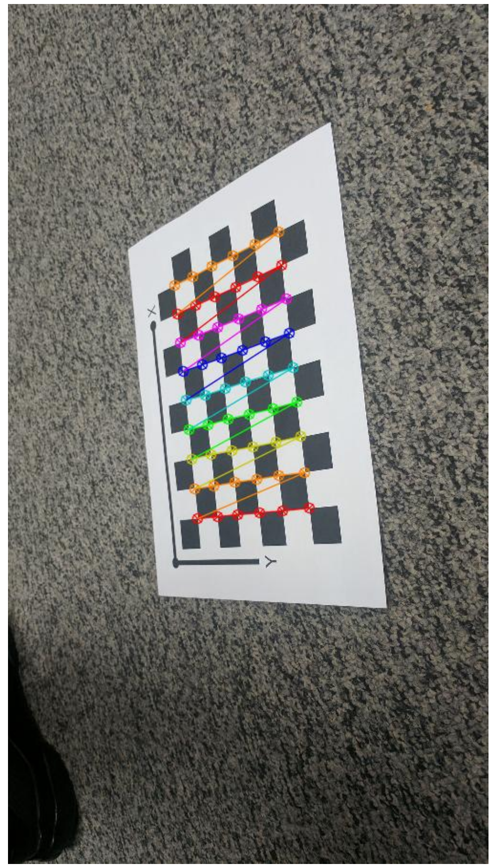

Fig. 2. Detected checkerboard 2

Image corner coordinates are extracted from each image in the calibration image dataset, and homographies between the corresponding world and image coordinates are estimated. Matrix V can be estimated for each image and stacked to obtain the 2nx6 matrix V, where n is the number of images. The initial closed form solution can be obtained by solving Vb=0 to get the matrix b = [B11, B12, B22, B13, B23, B33]. The matrix B is symmetric and so is fully determined by b. The nullspace of V is the eigenvector of (V.T).V associated with its smallest eigenvalue. The camera instrinsic matrix A was estimated from b. Extrinsic rotation and translation parameter matrices were calculated for each image using the values of lambda, A and the homography between the image and the world coordinates.

II. Maximum likelihood estimation

Maximum likelihood estimation was performed using least squares from the scipy optimize package, with the global sum of difference between the corner point and projected point of corners over all images. The closed form solutions of intrinsic and extrinsic parameters estimated in the previous section were used as the initial guess. The projected corner was obtained for each corner in each image by using the equation sm' = HM, with H = A[r1 r2 t], where r1, r2 and t are components of the extrinsic matrix estimated for that image. The radial distortion model in [1] was applied next, to get the final image.

The camera intrinsic matrix obtained was - [[2.05090103e+03 7.09029123e-01 7.55221289e+02] [0.00000000e+00 2.03785317e+03 1.35573900e+03] [0.00000000e+00 0.00000000e+00 1.00000000e+00]]

III. References

[1] Zhang, Zhengyou. ”A flexible new technique for camera calibration.” IEEE Transactions on pattern analysis and machine intelligence 22 (2000).