CMSC733: Computer Processing of Pictorial Information
Homework 1: AutoCalib!

Chahat Deep Singh
Robotics Graduate Student
University of Maryland
Email: chahat@umd.edu

***Abstract*—The following work is focused on easily calibrating a camera using Zhang's technique. The input required for the algorithm to work is only a few observation (at least two) of a planar pattern such as a checkerboard without even knowing the relative motion of the camera-pattern environment.**

I. Introduction

The following is the pipeline from Zhang's paper. [1]

II. The Algorithm

A. Estimating Homography between the Plane and its Image

$$s\begin{bmatrix}u\\v\\1\end{bmatrix} = A\begin{bmatrix}r_1 & r_2 & r_3 & t\end{bmatrix}\begin{bmatrix}X\\Y\\0\\1\end{bmatrix} = A\begin{bmatrix}r_1 & r_2 & r_3\end{bmatrix}\begin{bmatrix}X\\Y\\1\end{bmatrix}$$

where r_1, r_2 and r_3 form the rotational matrix R, t is the translation matrix, m is the 2D point denoted by $m = \begin{bmatrix}u & v\end{bmatrix}^T$ and X, Y and Z determines the position of the object in 3D space. In above equation, we assume the model plane on $Z = 0$ (Without any loss of generality).

Therefore, the homography H can be estimated by: $s\widetilde{m} = H\widetilde{M}$ where $H = A\begin{bmatrix}r_1 & r_2 & t\end{bmatrix}$

For other common notations, refer to [1]. Use the above equations and estimate K, R and t

B. Maximum-Likelihood Estimation

In this, we try to minimize the non-linear geometric error:

$$\Sigma^n \ \Sigma^m \ ||m_{ij} - \hat{m}(A, R_i, t_i, M_j)||^2$$

III. Conclusion

Got the reprojection error/ measurement of 0.529763 pixels.

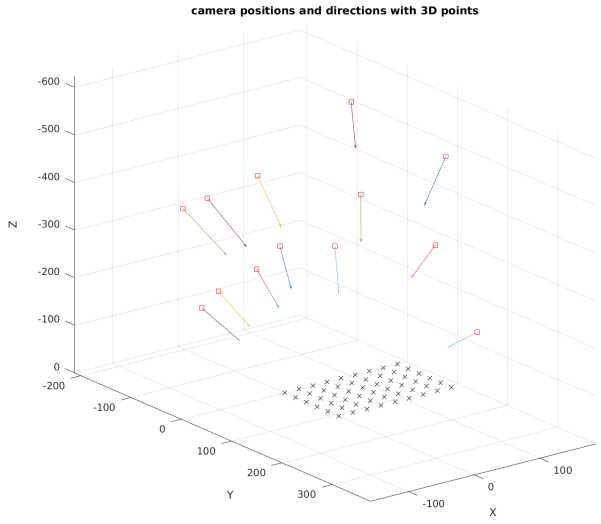

Fig. 1. Camera Posititon and direction with 3D points

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Reprojection error per measurement: 0.690529 pixel(s)

                                        First-Order                    Norm of
 Iteration  Func-count     Residual      optimality      Lambda          step
     0          99         5707.27        1.83e+05        0.01
     1         198          373.98        3.67e+03       0.001         13.213
     2         297         363.497        5.72e+03      0.0001        7.64743
     3         397         361.916             986       0.001        1.54595
     4         496         361.894             181      0.0001       0.447037
     5         596         361.893            70.3       0.001       0.244208
     6         695         361.893            8.56      0.0001        0.23929
     7         795         361.893            1.03       0.001       0.236687
     8         894         361.893           0.152      0.0001       0.141395
     9         995         361.893         0.00802        0.01      0.0187782
    10        1095         361.893         0.00105         0.1      0.00200958
    11        1195         361.893         0.00017           1      0.00021198
    12        1297         361.893        0.000274        1000     1.96695e-07
    13        1396         361.893        0.000154         100     2.45921e-07
    14        1504         361.893        0.000145       1e+11     3.72756e-15
    15        1605         361.893        0.000145       1e+13     3.67101e-17

Reprojection error per measurement: 0.529763 pixel(s)

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Fig. 2. Reprojection Error

References

[1] Zhengyou Zhang. A flexible new technique for camera calibration. *IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 22, NO. 11, NOV 2000.*