CS6790

Geometry and Photometry in Computer Vision

Assignment 2

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1 Introduction

In this assignment, we attempt to compute the camera calibration matrix K by computing the image of the absolute conic ω using perpendicularity relations and homography relations.

2 Question 1a

Here, we assume a full K matrix and compute it using 5 perpendicularity relations between vanishing points.

The Algorithm:

Find 5 distinct perpendicular direction pairs. Find vanishing points in each direction. If u and v are the vanishing points corresponding to 2 perpendicular directions, then u'ω v = 0.

$\omega = [\mathrm{w}_1, w_2, w_4; w_2, w_3, w_5; w_4, w_5, w_6];$

ω has 6 parameters, 5 free parameters because of the scaling factors. Hence, 5 unique constraints are required to find the image of the absolute conic. u'(ω)v = 0 leads to

$(\mathrm{u}_1 v_1, u_1 v_2 + u_2 v_1, u_2 v_2, u_1 v_3 + v_3 u_1, u_2 v_3 + u_3 v_2, u_3 v_3) w = 0 where w = (w_1, w_2, w_3, w_4, w_5, w_6).$

w can then be obtained using an SVD approach to find the least squares solution of the null space of the constraints matrix constructed.

The relation between the image of the absolute conic and the camera calibration matrix is $\omega = (\mathrm{KK}^T)^{-1}$.

Cholesky factorisation can be used to determine K.

Results:

Checker board images,img1:

Issue: Matrix not positive definite
img 7: K is
[529.91, -202.01, 754.8
0, 1074.89, 353.92
0,0,1]

3 Question 1b

Here, we again assume a full K matrix and compute it using 3 homography relations between a metric co-ordinate system xed to the scene plane and the image of the same. The 3 homography relations should correspond to planes which are NOT parallel to each other(they needn't be orthogonal though). This algorithm can't be applied to the chess board images because 3 non parallel planes for the homographies can't be found. Though img 1 and img 2 have 3 non parallel planes, this algorithm can't be applied there because we need to know a few parameters(like length of side of square,etc) in order to be able to determine the homography relation. This algorithm can be applied to img 7 and the checker board images because image 7 and the checker board images have squares in three non parallel planes using which 3 homographies can be found.
For each square, we find the homography relation that maps its corner points (0,0),(0,1),(1,0),(1,1) to their images points. This is done using normalised DLT as in assignment 1. Similarity transformation doesn't affect the position of the circular points on the plane and hence the alignment of the plane coordinate system with the square which is a similarity transformation doesn't matter. We now find the imaged circular points for the plane of the square as H(1,+i,0)' and H(1,-i,0)'.
H = [h$_1 h_2 h_3$] which implies that the imaged circular points are h$_1 + ih_2$ and h$_1 - ih_2$. These points lie on the IAC. applying which we get 2 equations:
h$_1'\omega$ h$_2 = 0$.
$h_1'\omega$ h$_1 = h_2'\omega$ h$_2$
$From five such equations, \omega$ is determined upto scale. K can then be computed.
Results:
Checker board images:
Issue: Matrix not positive definite
Img 7

, 0.8334, 469.3273
0, 1186.8717, 351.05
0, 0, 1.0

4 Question 2a

This is a modification of Q1a. We are asked to assume square pixels and zero skew. Therefore $\omega\ _12 = \omega\ _21 = 0.\omega\ _11 = \omega\ _22$.

$\omega = [\mathrm{w}_1, 0, w_2; 0, w_1, w_3; w_2, w_3, w_4];$

Here, IAC has only 3 free parameters and hence 3 constraints(3 perpendicular direction pairs) are enough. Each constraint gives us an equation of the form $(\mathrm{u}_1 v_1 + u_2 v_2, u_3 v_1 + u_1 v_3, u_2 v_3 + u_3 v_2, u_3 v_3)\mathrm{w} = 0$ which can be solved for ω and hence K.
Results:
Checker board Images:

[7098.358,0, 2502.05
0, 7098.358, 6265.18
0,0,1.0]
Img 1:

[7499.0072,0, 3311.680518
0, 7499.007231, 2047.582
0,0,1]
Img 2:

[13692.38, 0, 2509.9730
0, 13692.38, 2260.12
0,0,1]
Img 7:

[1177.01,0, 379.8566
0, 1177.01, 476.83
0,0,1]

5 Question 2b

Here, finding 2 homographies is enough as only 3 constraints are needed and each homography gives 2 constraints. As in Question 2a, this can be solved only for Img7.

Results:
Checker Board Images:

[3070.51,0, 2921.20
0, 3070.51, -3769.67
0,0,1.0]
Img 7:
[1180.64,0, 471.42
0, 1180.64, 306.90
0,0,1.0]

6 Conclusion

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Expected results are: skew s is very small compared to the other parameters. Principal point is in general half of the image size(eg. for a 1024 X 768 pixels image, we expect the principal point to be (512,384)). The focal length in the x and y directions are nearly equal.