Report of Computer Vision HW1

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一、Introduction

In this homework, we should try to know how camera work and relationship between 3D real world and image pixel. Main function of camera is transform 3D real coordinate to 2D image pixel. There are many parameters vary with cameras, each camera has its model like focus or distortion…. First of all, we should do camera calibration if we want to transfer from 3D coordinates to 2D image precisely.

Parameters of camera are divided into two part, first is intrinsic matrix and the other is extrinsic matrix. Intrinsic matrix includes the parameter of camera, and extrinsic matrix explain how to rotate and translate 3D world coordinate to 3D camera coordinate. Extrinsic matrix varies with the orientation and distance between camera and pictures, but the intrinsic matrix is the same if you use the same camera.

Next, we are going to introduce how to get the two matrices and use these to calibrate camera.

二、Implementation procedure

First of all, we have ten pictures about checkerboard, these can offer us very useful information. We can find the corners in these picture, simultaneously, corners in pixel offer us its coordinate in 2D image. Thus, this homework we get ten pictures about checkerboard, we can find the checkerboard corner in each picture by findcheckboard function in opencv.

After that, we record the 3D objection points and 2D image points into matrices ready to do the mathematical operation. Start from the definition HX=Y, and then $\mathrm{H}XX^T = YX^T \Rightarrow HXX^T(XX^T)^{-1} = \mathrm{Y}X^T(XX^T)^{-1} \Rightarrow H = \mathrm{Y}X^T(XX^T)^{-1}$, we have our objection points as X and image points as Y respectively so we can get Matrix H from above.

With Matrix H which is composed of intrinsic matrix and extrinsic matrix and some constraint ($h1^T K^{-T} K^{-1} h2 = h1^T B h2$ = Vb = 0, which B is

$$\begin{bmatrix} B11 & B12 & B13 \\ B12 & B22 & B23 \\ B13 & B23 & B33 \end{bmatrix}, b\ is\ \begin{bmatrix} B11 \\ B12 \\ B13 \\ B22 \\ B23 \\ B33 \end{bmatrix}, \mathrm{H} = [\mathrm{h1}\ \ \mathrm{h2}\ \ \mathrm{h3}]_{3*3}$$

), we get V from the inferred relationship between V and H

$$\mathrm{h}_i^T \mathrm{B}\mathrm{h}_j = v_{ij} b = \begin{pmatrix} h_{i1}h_{j1} \\ h_{i1}h_{j2} + h_{i2}h_{j1} \\ h_{i2}h_{j2} \\ h_{i3}h_{j1} + h_{i1}h_{j3} \\ h_{i3}h_{j2} + h_{i2}h_{j3} \\ h_{i3}h_{j3} \end{pmatrix}^{\mathrm{T}} \begin{pmatrix} \mathrm{B}_{11} \\ \mathrm{B}_{12} \\ \mathrm{B}_{22} \\ \mathrm{B}_{13} \\ \mathrm{B}_{23} \\ \mathrm{B}_{33} \end{pmatrix}^{\mathrm{T}} = \begin{pmatrix} v_{12}^{\mathrm{T}} \\ (v_{11} - v_{22})^{\mathrm{T}} \end{pmatrix} b = vb = 0$$

Since we have V and solving Vb = 0, we now obtain the entire Matrix B. What we need to do is using Cholesky decomposition to get intrinsic matrix and then multiply its inverse on the left of Matrix H to get the extrinsic matrix.

After all, we can describe an image from 3D world coordinate to 2D pixel coordinate with these two matrices, intrinsic matrix and extrinsic matrix.

三、Experimental result

Unfortunately, we are not able to complete the project before the deadline, but I think the Homography H is correct according to our examination. Hope we can finish this project in the next few days.

四、Discussion

Being trapped in finding the right Matrix B, we discuss many methods like, SVD decomposition, least square, and asking the TA for help.

五、Conclusion

With this experience doing the project, we understand the procedure of camera calibration more, and we know exactly why we should to do the calibration which is for eliminating the distortion caused by camera.

六、Work assignment plan between team members

0756067 培倫: Collecting the related information, coding, and report writing.

0751906 偉嘉: Coding, report writing, and result examining.

0751917 仰毅: Mathematical derivation, coding, and report writing.

We all code the project so we got three version code but we are all in the dilemma to get right b. Although we discuss it and try many methods, those all in vain.