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Autocalibration Report

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1 Introduction

Camera calibration with known patterns or objects with know euclidean structures are very well known and used techniques. However these methods are not available without priori assumptions to calibrate and get intrinsic parameters. Hence, we need to use autocalibration techniques that doesn't rely on euclidean structures for calibration.

Why it's important?

For instance, in 3D reconstruction, the recovery of the calibration parameters of the cameras is significant since it provides metric information about the observed scene, e.g., measures of angles and ratios of distances. Auto-calibration enables the estimation of the camera parameters without using a calibration device (e.g., checkerboard), but by enforcing simple constraints on the camera parameters, such as constant intrinsic parameters in multiple images, known principal point, known pixel shape, etc.

2 Algorithms for camera auto-calibration

- The simplified and classical Kruppa's equations.
- The Mendonça-Cipolla auto-calibration method.
- Using the absolute dual quadric and its projection, the dual image of the absolute conic.

3 Methods

We have been given approximate intrinsic parameter of the camera, fundemental matrixes between the images, projection matrix between the images. We employ 3 dierent method below to more accurately approximate intrinsic parameters.

3.1 Kruppa Equations

Kruppa equations are obtatining intrinsic parameters of the camera using polynomial equations, with a minimum of three displacements. I had hard time to achieve good results without passing the tolerance, and some more parameter values for lsqnonlin function.

The solution to camera intrinsic parameters for Kruppa's method can be computed by solving the optimization problem for the cost function given below,

$$\mathcal{C}(\alpha_u, \alpha_v, \gamma, u_0, v_0) = \sum_{i,j} \left|\left| \frac{\mathbf{F}_{ij}\boldsymbol{\omega}^{-1}\mathbf{F}_{ij}^T}{||\mathbf{F}_{ij}\boldsymbol{\omega}^{-1}\mathbf{F}_{ij}^T||_{fro}} - \frac{[\ \mathbf{e}_{ji}\ ]_\times \boldsymbol{\omega}^{-1}[\ \mathbf{e}_{ji}\ ]_\times^T}{||[\ \mathbf{e}_{ji}\ ]_\times \boldsymbol{\omega}^{-1}[\ \mathbf{e}_{ji}\ ]_\times^T||_{fro}} \right|\right|_{fro}$$

where $||.||_{fro}$ refers to the Frobenius norm.

800.008699400211	-0.000841395721280208	256.000110817581
0	800.00842085238	256.000185844728
0	0	1

Table 1: Kruppa Equations Intrinsic Parameter Approximation

This is implemented by function,

function [C] = kruppaCost (X, Fs)

3.2 Mendonca and Cipolla

Basic method based on the exploitation of the rigidity constraint. We design cost function, which takes intrinsic parameters and fundemental matrices as parameters, and returns positive value related to difrence between two non-zero singular value of the essential matrix.

800.018875334029	-0.00111165444322615	255.996941864705
0	800.019278207122	256.001480852401
0	0	1

Table 2: Mendonca Cipolla Intrinsic Parameter Approximation

This is implemented by function,

function [C] = mendoncaCipol laCost (X, Fs)

3.3 Dual Absolute Quadric

We represent euclidean scene structure formulated in terms of the absolute quadric - the singular dual 3D quadric giving teh Euclidean dot-product between plane normals.

Here, the idea is to find the plane at infinity using Dual Absolute Quadric (DAQ) and initial guess of intrinsic parameters.

This is done solving the equation,

$$\mathbf{M}_j \mathcal{Q} \mathbf{M}_j^T \simeq \omega^{-1} \quad \text{where} \quad \mathcal{Q} = \begin{pmatrix} \omega^{-1} & \omega^{-1}\mathbf{n}_\Pi \\ \mathbf{n}_\Pi^T\omega^{-1} & \mathbf{n}_\Pi^T\omega^{-1}\mathbf{n}_\Pi \end{pmatrix}$$

where, M is camera matrix, Q is DAQ, w = AAT and ’n’ is normal to plane at infinity.

So by solving this equations by some scale factor ’lambda’ and initial guess we can find the plane at infinity and also ’lambda’.

4 Conclusion

These methods provide a powerful tool to find the intrinsic parameters of camera for auto calibration even if we don’t have a pattern for calibration of camera as we generally have for calibration.

5 References

https://en.wikipedia.org/wiki/Camera_auto-calibration
http://homepages.inf.ed.ac.uk/cgi/rbf/CVONLINE/entries.pl?TAG1325
http://hal.inria.fr/docs/00/54/83/45/PDF/Triggs-cvpr97.pdf