Camera Autocalibration Lab

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A scene has been imaged 10 times by a moving (pinhole) camera with constant intrinsic parameters. The fundamental matrices $\mathbf{F}_{ij}$ relating all pairs of views have been accurately calculated using our favorite method. We have also been able to calculate the projective projection matrix $\mathbf{M}_i$ of each camera i. A prior, but rough, calibration of the camera (which we have carried out ourselves to save you the hassle) has provided very approximate values of the intrinsic parameters (matrix $\mathbf{A}$) which can be used as an initial guess for camera autocalibration. However, for the targeted application, more accurate intrinsic parameters are required.

The projective projection matrices, the fundamental matrices and the approximate intrinsic parameters can be downloaded from

`http://sites.google.com/site/vibot3d/`

1. Download the file `data.mat` to your work folder,
2. use the Matlab command `format long;` at the very beginning of your program,
3. use the Matlab command `load('data.mat')` to load the content of the file,
4. `PPM(:,:,i)` is the projective projection matrix of camera i, $i = 1 \ldots 10$,
5. `Fs(:,:,i,j)` is the fundamental matrix between cameras i and j,
6. `A` contains the approximate values of the intrinsic parameters obtained through prior calibration.

Work to be done:

It is your turn now to roll-up your sleeves to reveal the true intrinsic parameters of the camera that captured the scene through camera autocalibration. We would like you to test the following methods:

1. The Mendonça-Cipolla autocalibration method described in Lecture 05: use `A` as initial estimate and assume all pairs of images weigh the same on the process.
2. The classical and simplified Kruppa's equations (Lecture 03): use `A` as initial estimate.
3. The Dual Absolute Quadric (Lecture 04): an extra step is needed here to obtain an estimate of the plane at infinity given the estimate of `A`.

What to submit:

1. your source code,
2. a short report (1 or 2 pages in pdf format) describing your work, your results, the problems you have been confronted to and how they were dealt with.

Where to submit:

`autocalibration@gmail.com`

Hints and guidelines:

1. If you use Matlab (which I strongly suggest you do), you can use:
   - ▷ `lsqnonlin` to perform nonlinear least-squares optimization (preferably choose the Levenberg-Marquart algorithm),
   - ▷ if, for some reason, `lsqnonlin` is giving you headaches, use `fminsearch` (an easy to use, but less efficient, optimization function that is based on Nelder-Mead algorithm),
   - ▷ if you are minimizing some cost function subject to some linear or nonlinear constraints, use `fmincon`,
   - ▷ for the above Matlab functions - or any other function for that matter - use Matlab help.
2. Should you be implementing the "Mendonça & Cipolla" method, consider all the weights $w_{ij} = 1$.
3. Should you be using a method that requires approximate knowledge of the plane at infinity, you can extract approximate coordinates of the plane at infinity using the Dual Absolute Quadric equations and the approximate values of $\mathbf{A}$ provided in `data.mat` (linear equations - SVD).
4. You may want to use `Maple` to manipulate symbolic expressions and turn them into Matlab code.
5. The relevant literature you may want to take a look at is posted on the website. You may also want to refer to one or more of the following papers [5, 8, 6, 2, 9, 1, 7, 3, 4] for additional details.

References

[1] A. Fusiello. Uncalibrated euclidean reconstruction: A review. *Image and Vision Computing*, 18(6-7):555–563, May 2000.

[2] A. Fusiello. A new autocalibration algorithm: Experimental evaluation. In W. Skarbek, editor, *Computer Aanalysis of Images and Patterns*, volume 2124 of *Lecture Notes in Computer Science*, pages 717–724. Springer-Verlag, 2001.

[3] R. I. Hartley. Kruppa's equations derived from the fundamental matrix. IEEE *Transactions on Pattern Analysis and Machine Intelligence*, 19(2):133–135, February 1997.

[4] R. I. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, ISBN: 0521540518, second edition, 2004.

[5] M.I.A. Lourakis and R. Deriche. Camera self-calibration using the singular value decomposition of the fundamental matrix. In *Proceedings of the Asian Conference on Computer Vision, Taipei, Taiwan*, volume 1, pages 403–408, January 2000.

[6] Q.T. Luong. Self-calibration of a moving camera from point correspondences and fundamental matrices. *International Journal of Computer Vision*, 22(3):261–289, 1997.

[7] P. R. S. Mendonça and R. Cipolla. A simple technique for self-calibration. In *Proceedings of the Conference on Computer Vision and Pattern Recognition, Fort Collins, Colorado, USA*, volume 1, pages 500–505, June 1999.

[8] M. Pollefeys and L. Van Gool. Stratified self-calibration with the modulus constraint. IEEE *Transactions on Pattern Analysis and Machine Intelligence*, 21(8):707–724, August 1999.

[9] B. Triggs. Autocalibration and the absolute quadric. In *Proceedings of the Conference on Computer Vision and Pattern Recognition, Puerto Rico, USA*, pages 609–614, June 1997.