FULLY AUTOMATIC AND ROBUST UAV CAMERA CALIBRATION USING CHESSBOARD PATTERNS

Koen Douterloigne

Koen.Douterloigne@telin.ugent.be
Belgium, Ghent University, IBBT-Telin-IPI

1. PROBLEM

The use of lightweight, cheap UAV's equipped with a camera for mapping land coverage and creating orthophotos is rapidly gaining popularity. Cameras used in a UAV often have the requirement to be light, which results in sometimes large image deformations due to lens distortions. Because of this it is important to know both the intrinsic and the distortion parameters of the camera when generating an accurate orthophoto, in order to compensate for these distortion effects. Without the correct distortion parameters the stitched image mosaic may contain gross errors, especially near the edges where the images overlap. Most commercial mosaicing software requires these camera calibration parameters as an explicit input.

2. RELATED WORK

Much work has been done around automatic and semi-automatic camera calibration [1-2]. A popular method for camera calibration uses a planar object with a chessboard pattern, which is imaged from different angles. In each view of the object, the pixel coordinates of all the chessboard corner points are extracted, and mapped to their 3D world coordinates. Then based on these correspondences the camera intrinsic and distortion parameters are calculated by minimizing the backprojection error, using an iterative optimization process [3]. It is of course impossible (or very impractical) to know the exact 3D position of the corner points. For this reason the coordinates are determined up to a rotation and translation of the 3D space. The XY-plane (where $Z = 0$) is placed in the plane of the chessboard, and the (X,Y) coordinate of each point is simply the index of that point on the chessboard.

Commercial and free software applications, like OpenCV or the Matlab calibration toolbox [4], successfully use this method, but still require some knowledge and time from the user, and also have their limitations. Especially cameras with a narrow field of view give problems, as the chessboard must be completely visible in order to automatically get the (X,Y) world coordinates of the corner points. If it is not fully visible, the user has to supply these world coordinates manually, often a time intensive task.

3. PROPOSED METHOD

In this paper we present a fully automatic calibration method based on chessboards, requiring no user interaction other than supplying the input data, even if the boards are only partially visible. The general idea behind the method is to gradually grow a grid of points, in which each point has an (X,Y) coordinate based on its position in the grid.

To do this we first extract all the chessboard corner points from the image, using the classical adaptive threshold algorithm as used by OpenCV [5]. Then we randomly select one of the points as the starting point. We find its closest neighbours and construct a small grid of points with those. Next we compute the viewing angle parameters of this small grid (with least squares), and expand it into a global grid. By comparing this global grid with our corner points, we give grid coordinates to additional points that are close to the global grid. Using these newly added points we recompute the parameters of the point grid, and again create the global grid. Repeating this process, we iteratively add points to the point grid until eventually all points have a set of coordinates.

This method is quite robust, even when parts of the chessboard pattern are obscured or are out of view. However the method does sometimes end up in an incorrect local minimum, for example when the extracted points are incorrect due to noise in the image. We can detect and remove these failed views, by filtering out the views with a too high backprojection error. Finally we will repeat the calibration with only correct views, giving very accurate results for the intrinsic and distortion parameters, without any user interaction required.

4. REFERENCES

[1] R. Y. Tsai, “An Efficient and Accurate Camera Calibration Technique for 3D Machine Vision,” *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition*, pp. 364 – 374, 1986.

[2] B. Triggs, “Autocalibration from planar scenes,” *Proceedings of 5th European Conference on Computer Vision*, pp. 89 – 105, 1998.

[3] Z. Zhang, “A flexible new technique for camera calibration,” *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 22, no. 11, pp. 1330 - 1334, 2000.

[4] J. Bouguet, “Camera Calibration Toolbox for Matlab,” *http://www.vision.caltech.edu/bouguetj/calib_doc/*.

[5] “Open Computer Vision Library,” *http://sourceforge.net/projects/opencvlibrary/*.