Comparing Self-Calibration Methods for Static Cameras

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Extended Abstract

Many methods have been developed in the last few years to self-calibrate cameras, but few works have addressed a comparison of such methods to provide the user with hints on the suitability of certain algorithms under particular circumstances. The few of these works that analyze self-calibration methods have concentrated on the study of the influence of some factors [1] [2] or the identification of critical movements [3], but there are not any studies analyzing the accuracy and stability of these methods.

This work presents a comparative analysis of four methods of self-calibration for cameras which only rotate (without translation movement): McLauchlan's method [4] that assumes that the camera setup is fixed along the sequence; and Agapito's methods (linear [5] and iterative [6] algorithms) and Seo's method [7] that allow the variation of optic center and scale factors.

The experiments discussed in this paper have focused on characterizing the accuracy in the point reconstruction (global error) and the stability and accuracy of the estimation of the internal camera parameters. These experiments were performed with both a real camera and a simulator.

When only the extrinsic parameters vary in a sequence used to calibrate a camera the estimated values for the intrinsic parameters in each image of this sequence should be the same. The variability in the estimation of the intrinsic parameters along the sequence was measured to know the stability of the methods. The experiments carried out showed that, despite the camera configuration was kept constant along the sequence, there were variations across all methods by intrinsic parameters. For example, this variability represented 4% of the ground truth value in the optic center when simulated images was used and 3% when real images were analyzed. Additionally, the estimated values of intrinsic parameters obtained by the methods had differences between them, especially in the scale factors (4% using simulated data and 2.5% using real data).

In the simulator, the accuracy of each parameter could be analyzed. It was observed that the versions of Agapito's method obtained values closer to ground

truth value of the optic center than Seo's method. McLauchlan's method obtained a high accuracy in scale factor due to the fact that it estimates only one value for all the sequence and the remaining methods studied presented a little inaccuracy (4.5%). However, the global error of McLauchlan's method had the highest value and Agapito's method obtained a very low level for this error.

In real conditions, the results of these self-calibration methods were compared with a manual calibration method (Batista's method [8])). In general, while the manual method offered more stable results across the sequence, the performance of the self-calibration methods was comparable to that achieved by Batista's method. The self-calibration method that obtained closer values to this method was McLauchlan's method, which turned out to be the most precise method in the simulator.

Finally, the effect of the length of the sequence in the accuracy of each parameter was studied. The results showed that 30 images were enough to obtain minimum levels of errors in all methods, but McLauchlan's method, although it had less error, needed more images to minimize the error. On the other hand, when the run time was compared, it could be observed that Seo's method had a high computational cost, especially in long sequences.

To summarize, the experiments carried out have shown that the optic center is the most unstable parameter for all methods and that the larger discrepancies among the estimated values appear with the scale factors. Also, the results returned by any of these methods are comparable in terms of stability and accuracy with those provided by a well-known manual calibration method.

References

1. Hayman, E., Murray, D.: The effects of translational misalignment when self-calibration of rotating and zooming cameras. IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) **25**(8) (August 2003) 1015–1020
2. Wang, L., Kang, S., Shum, H.Y., Xu, G.: Error analysis of pure rotation-based self-calibration. IEEE Transactions on Pattern Analysis and Machine Intelligence **26**(2) (Febrery 2004) 275–280
3. Sturm, P.: Critical motion sequences for monocular self-calibration and uncalibrated euclidean reconstruction. In: Conf. Computer Vision antd Pattern Recognition. (1997) 1100–1105
4. Mclauchlan, P., Murray, D.: Active camera calibration for a head-eye platform using the variable state-dimension filter. IEEE Transactions on Pattern Analysis and Machine Intelligence **18**(1) (January 1996) 15–22
5. de Agapito, L., Hartley, R., Hayman, E.: Linear calibration of a rotating and zooming camera. In: CVPR99. (June 1999)
6. de Agapito, L., Hayman, E., Reid, I.: Self-calibration of a rotating camera with varying intrinsic parameters. In: Proc. British Machine Vision Conference. (1998) 105–114
7. Seo, Y., Hong, K.: Auto-calibration of a rotating and zooming camera. In: Proc. of IAPR workshop on Machine Vision Applications. (November 1998) 17–19
8. Batista, J., Arajo, H., de Almeida, A.: Iterative multi-step explicit camera calibration. In: Proc. Sixth International Conference on Computer Vision ICCV98. Volume 15. (January 1998) 709–714