Camera Autocalibration

Assignment

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Introduction

The classical camera calibration uses images of an object with known euclidean structure to get the intrinsic parameters of the camera. This technique is widely used but there are cases where the intrinsic parameters change or the euclidean structure might not be available. In these cases one needs to employ an automatic calibration method that does not need any euclidean structure for calibration. Also even if the euclidean reconstruction of the scene is possible the intrinsic parameters might be wrong. For those reasons we need self calibration methods. This report covers the explanation of one of the self-calibration techniques called the "Mendonça and Cipolla" method[1]. The reason for choosing this method is that it is fairly easy to implement and understand compared with the other methods in the references of the assignment.

Method

The method is based on the conditions that has to be satisfied by the singular values of an essential matrix introduced by Hartley[2] and proved by Huang and Faugeras[3]. These conditions are:

- Two singular values must be identical.
- The essential matrix must be rank two and the remaining singular values must be zero.

Huang and Faugeras also showed that the equalities of the singular values imposes two algebraic constraints depending of the essential matrix. Hartley exploited the relation between the essential matrix, the intrinsic parameters of the cameras and the fundamental matrix by;

$$E = K_2^T F K_1$$

where E is the essential matrix, F is the fundamental matrix and K_1 and K_2 are the calibration matrices(intrinsic parameters) of the two cameras.Note that since the fundamental matrix has rank two and the calibration matrices have full rank algebraically the second condition shown above is satisfied.

According to satisfy the first condition that, two singular values must be identical, we need the intrinsic parameters of the camera. Thus K_1 and K_2 becomes the calibration matrices of the camera. More specifically;

The calibration matrices of cameras i and j can be parametrized as;

$$K = \begin{pmatrix} \alpha_x & s & u_0 \\ 0 & \varepsilon\alpha_x & v_0 \\ 0 & 0 & 1 \end{pmatrix}$$

where α_x is the product of focal length and magnification factor, ε is the aspect ratio, $[u_0 v_0]^T$ are the coordinates of the principal point and s is the skew.

Finally the cost function to be minimized is proposed by the authors is;

$$C(K_i, i = 1, ..., n) = \sum_{ij}^{n} \frac{w_{ij}}{\sum_{kl}^{n} w_{kl}} \frac{\sigma_{ij,1} - \sigma_{ij,2}}{\sigma_{ij,2}}$$

where w_{ij} is a degree of confidence in the estimation of the fundamental matrix F_{ij} (the fundamental matrix relating images i and j of the sequence) and $\sigma_{ij,1}$ and $\sigma_{ij,2}$ are the **non-singular** values of $K_j^T F_{ij} K_j$. Since we have a non-linear system we will employ the Levenberg-Marquart algorithm.

The approximate values of the intrinsic parameters(A) obtained through prior calibration are;

$$A = \begin{pmatrix} 870.2582716108395 & 0 & 279.1007468913193 \\ 0 & 812.1786285338063 & 260.9300502222471 \\ 0 & 0 & 1.0000000000000 \end{pmatrix}$$

The resulting intrinsic parameters(A_{new}) after the algorithm applied are;

$$A_{new} = \begin{pmatrix} 800.1927713384639 & 0 & 255.9779665993093 \\ 0 & 800.2344176791441 & 256.0100847633528 \\ 0 & 0 & 1.0000000000000 \end{pmatrix}$$

Conclusions

In conclusion the "Mendonça and Cipolla" method has implemented. The method is very easy to implement. Also it is easy to understand when we make rough comparison between the other reference methods mentioned in the assignment.

References

[1] P. Mendonca and R. Cipolla, *A simple technique for self-calibration,* in CVPR99, 1999

[2] R. Hartley. *Estimation of relative camera positions for un-calibrated cameras.* In Proc. 2nd European Conf. on Computer Vision, Lecture Notes in Computer Science 588, pages 579587, 1992.

[3] T. S. Huang and O. Faugeras. *Some properties of the E matrix in two-view motion estimation.* IEEE Trans. Pattern Analysis and Machine Intell.