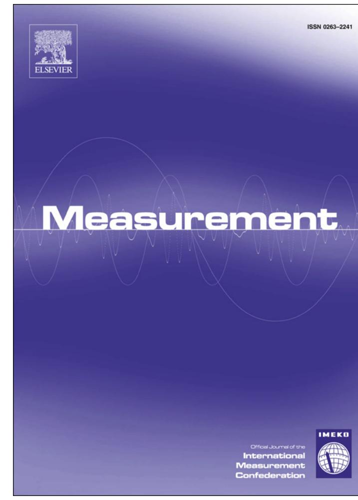

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PII: S0263-2241(18)30724-3
DOI: https://doi.org/10.1016/j.measurement.2018.07.085
Reference: MEASUR 5769

To appear in: *Measurement*

Received Date: 28 March 2018
Revised Date: 28 May 2018
Accepted Date: 26 July 2018

A single-image linear calibration method for camera

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Abstract: This paper proposes a linear method for simultaneously calibrating the distortion coefficients and intrinsic parameters of a camera by using a single image, based on the division model of distortion. First, we accurately estimate the distortion center from correspondences between points on the target and its image. Then we decouple the distortion coefficient and intrinsic parameters and solve all the parameters independently through a linear method. We show through both simulation and real experiments that the proposed approach is effective and reliable. Compared with iterative methods, it can improve computational efficiency by more than 20 times while preserving calibration accuracy.

Keyword: Camera Calibration; Lens Distortion Correction; Division Model; Non-Iterative

1. Introduction

With the development of computer technology, machine vision has been widely applied in various fields that have a high requirement for intelligence. When the spatial information on objects is obtained by vision, the intrinsic parameters and distortion coefficients of the camera need to be estimated in advance [1]. This estimation process is known as the camera calibration. At the same time, the accuracy and timeliness of camera parameters estimation directly affect the application scenarios of vision systems such as hand-eye robots [2], visual SLAM [3], and vision-based pose measurement systems [4]. Thus, a high-accuracy simple calibration method is of high significance.

Presently, the camera calibration methods can be divided into two major categories. The first category includes the target-based calibration methods which usually relate to the imaging of known targets, and determination of camera parameters according to the two-dimensional (2D)-three-dimensional (3D) correspondence relationship. This kind of methods is suitable for the calibration in accurate dimensional measurements. The other category includes the self-calibration methods that do not need targets. Namely, these methods use some mathematical characteristics to estimate the intrinsic and external parameters of a camera such as specific motion patterns [5] and vanishing points [6, 7]. However, the self-calibration methods have certain limitations on the scene and movement, and the calibration accuracy is relatively low. Therefore, the focus of this work is on the first type of methods.

One of the calibration method based on the target was proposed by R. Y. Tsai in [8]. He established the classic Tsai camera model and proposed a two-step calibration method. J.Weng [9, 10] improved the Tsai model so that it could accommodate lens distortion. Later on, Horn [11] and Silva [12] independently developed robust methods that used a combination of optimization techniques. In 1999, Zhang [13] proposed a more convenient calibration method, which uses a non-linear method to solve the distortion parameters achieving the high precision. Ever since, the methods and theories of camera calibration have gradually matured, and most of the latter methods are based on the Zhang's camera model [13]. Namely, Anchini [14] presented a novel system to calibrate close range cameras. Pitchandi et al.[15-17] use a convolutional neural network for camera calibration. Q.S. Wang [18,19] added some limitations to the camera model to improve the efficiency of calibration process. Besides, some non-iterative calibration methods were also proposed.[20,21] , and these methods usually are based on a planar target. In these calibration processes, multiple