Journal Pre-proofs

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PII: S0263-2241(19)31269-2
DOI: https://doi.org/10.1016/j.measurement.2019.107402
Reference: MEASUR 107402

To appear in: *Measurement*

Received Date: 25 August 2019
Revised Date: 20 November 2019
Accepted Date: 14 December 2019

Please cite this article as: D. Qiu, S. Li, T. Wang, Q. Ye, R. Li, K. Ding, H. Xu, A High-Precision Calibration approach for Camera-IMU Pose Parameters with Adaptive Constraints of Multiple Error equations, *Measurement* (2019), doi: https://doi.org/10.1016/j.measurement.2019.107402

A High-Precision Calibration approach for Camera-IMU Pose Parameters with Adaptive Constraints of Multiple Error equations

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Abstract： In the calibration of the pose parameters of a camera and inertial measurement unit (Camera-IMU), the camera depth information is unreliable due to the uneven spatial distribution of calibration points, because the calibration points have random errors due to the IMU drift and the inadequate robustness of stereovision and because the Camera-IMU pose parameters lack self-adaptation. This paper proposes a high-precision calibration approach for Camera-IMU pose parameters with adaptive constraints of multiple error equations (adaptive constraint calibration approach, ACCA). The approach calibrates pose parameters of the Camera-IMU jointly via error equations, such as lens distortion correction, camera parallax correction and error compensation of the inertial sensor. The experimental results show that the calibration approach for Camera-IMU pose parameters with adaptive constraints of multiple error equations improves the measurement accuracy by 84.0% and can effectively suppress IMU drift with good robustness.

Key words: Stereovision; Inertial measurement unit; Quaternion; Newton method; Binocular vision mobile measurement sensor system.

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1. Introduction

Binocular vision mobile measurement sensor system takes automobile as mobile platform and carries Global Navigation Satellite System (GNSS), inertial measurement unit (IMU) and Charge-coupled Device (CCD) digital cameras. Binocular vision mobile measurement sensor system has the ability of direct geolocation. Combining with CCD digital camera, it can complete the task of 3D coordinate acquisition of target point space. Camera and inertial measurement unit (Camera-IMU) pose parameter calibration is the core of the binocular vision mobile measurement sensor system. High-precision Camera-IMU pose parameters reduce the time required for data acquisition, increasing productivity, data quality and accuracy.

A binocular vision mobile measurement sensor system acquires three-dimensional coordinate data of feature points through stereo imaging of images collected by binocular vision sensors [1-2]. The accuracy, robustness and reliability of the system in acquiring three-dimensional coordinate data are determined by the accuracy of pose parameters between the camera and inertial measurement unit.

Jorge Lobo et al [3] adopt a two-step method. The first step is to place the calibration plate vertically, use the camera to obtain the vertical vector, and use the IMU to measure the acceleration of gravity in the static state to obtain the rotation parameters of the Camera-IMU. Then they placed the IMU on a rotating platform, coincide the center of the camera with the center of the IMU, and