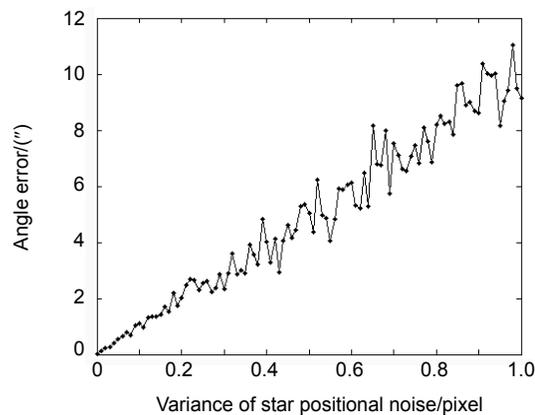


An on-orbit calibration model for wide field of view star sensor based on the vector observations

Xiaobo Yuan^{1,2} and Chao Zhang^{1*}

¹ Institute of Navigation & Aerospace, Information Engineering University, Zhengzhou 450001, China;

² Beidou Navigation Technology Collaborative Center of Henan, Zhengzhou 450001, China



The star position error's influence on star angle error.

Abstract: It is urgent to develop high precision calibration model for wide field of view star sensor. It is hard to calculate the camera parameters precisely by using the traditional methods because of large optical aberration. Focused on the on-orbit calibration problem of the wide field of view star sensor, a novel calibration model based on vector observations is proposed. Rodriguez matrix is introduced into the model, and 3 Rodrigues parameters instead of Euler angles, are represented as the exterior parameters to simplify the calculation. The distortion parameters are extended to third order in order to describe the distortion more precisely. Then a joint calculation of intrinsic parameters, exterior parameters and distortion parameters are completed by the model. The performance of the model is analyzed by simulation star map, and result shows that the model has a higher accuracy than the traditional model with Euler angles. In case of a standard deviation of 0.05 pixels star point error, the model can still accurately calculate the camera parameters, and the angle error after calibration is 0.483 arcsecond, and the mean residual errors are 0.019 pixels in x direction and 0.016 pixels in y direction, respectively. Furthermore, the initial parameters are simpler and there is no need to set initial value, and no precise prior attitude information is needed in the calibration process, which will be of great convenience for the practical applications. Its accuracy is further verified by actual star maps of ZY-3 satellite, and result shows that the statistical deviation of star angle after the calibration is 2.376 arcsecond, and the mean residual errors are 0.257 pixels in x direction and 0.151 pixels in y direction respectively, which improve the calibration accuracy largely. Further research on precision analysis is conducted as well. The main procedure is as bellow: Firstly, the Gaussian white noise with the standard deviation of 0 to 1 pixel by steps of 0.01 pixels is added to the star point position, and then the mean value of precision indexes of 100 experiments is calculated. The result shows that the star extraction precision of actual star map is about 0.20 pixels to 0.33 pixels, and to further improve the calibration accuracy, higher precision centroid algorithm is recommended in actual applications.

Keywords: calibration; wide field of view star sensor; vector observations; Rodrigues parameters; Euler angles

Citation: Yuan Xiaobo, Zhang Chao. An on-orbit calibration model for wide field of view star sensor based on the vector observations [J]. *Opto-Electronic Engineering*, 2017, 44(5): 505-510.

See page 505 for full paper.