光学精密工程 » 2015, **Vol. 23** » Issue (10): 2927-2942 DOI: 10.3788/OPE.20152310.2927

航空变焦距斜视成像几何畸变的自动校正

周前飞[1,2], 刘晶红[1], 王宣[1,2], 孙明超[1]

1. 中国科学院 长春光学精密机械与物理研究所 中国科学院航空 光学成像与测量重点实验室, 吉林 长春 130033;
2. 中国科学院大学, 北京 100049

Automatic correction of geometric distortion in aerial zoom squint imaging

ZHOU Qian-fei[1,2], LIU Jing-hong[1], WANG Xuan[1,2], SUN Ming-chao[1]

1. Key Laboratory of Airborne Optical Imaging and Measurement, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033, China;
2. University of Chinese Academy of Sciences, Beijing 100049, China

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全文: PDF (2592 KB) RICH HTML NEW

输出: BibTeX | EndNote (RIS)

摘要 针对变焦距航空摄像机斜视成像产生的几何变形,提出一种同时校正斜视梯形失真和变焦距镜头非线性畸变的自动校正方法。根据直线透视投影不变性原理,利用单参数除式模型通过变步长优化搜索方法得到不同焦距对应的镜头畸变系数和畸变中心坐标;研究了焦距变化对畸变的影响规律,校正了镜头畸变使其满足针孔成像模型;引入飞机位置、姿态和摄像机视轴指向方位等因素,将航空图像重投影到地图坐标系中,对坐标变换后的像素亮度值进行重采样得到校正斜视变形和镜头畸变后的正射投影图像。对不同焦距和位置姿态下拍摄的地面靶标畸变图像和实际航空变焦距斜视图像进行了校正。结果表明,该方法能够有效准确地校正图像的几何变形,当飞行高度为2 500 m时,在文中给定的位置姿态精度下的图像几何校正均方误差约为2 m,较好地满足了后续图像拼接需求。该方法效率高,便于自动化实现,对提高图像拼接精度和实现目标精确定位与实时稳定跟踪具有重要意义。

关键词 : 变焦距斜视成像, 几何校正, 镜头畸变, 除式模型, 摄像机标定

Abstract : For geometric distortion caused by squint imaging of a zoom aerial camera, an automatic simultaneously correction method for both squint trapezoidal distortion and nonlinear distortion of the zoom lens was proposed. Based on the same geometric type between straight line and its ideal projection image, the one-parameter division model was adopted to estimate the distortion coefficient and the distortion center coordinates at different focal lengths by an optimization searching method of variant step length. The effects of focal distance change on the distortion coefficient and distortion center coordinates were researched, then the lens's distortion was corrected to satisfy the ideal pinhole imaging model. By introducing the position and attitude of airplane and the pointing azimuth of the optical axis for the camera, the oblique aerial images specified in the camera frame were georectified into the mapping frame. The pixel intensity after coordinate transformation was resampled to obtain orthorectified images without the lens distortion and squint distortion. The correction experiments were performed for the distortion patterns captured under various focal lengths, positions and attitudes and the actual aerial zoom oblique images, and the results show that this method effectively and accurately corrects the geometric distortion of images. The Root Mean Square Error (RMSE) of image geometric correction is about 2 m when the flight height is 2 500 m with the position and attitude measurement precision given in this article.The precision satisfies the requirements of the follow-up image mosaicing. It concludes that the method is more efficient, easy to realize in automation and has great significance for promoting aerial image mosaicing precision, implementing fast positioning and real-time tracking of moving objects.

Key words : zoom squint imaging mode geometric correction lens distortion division model camera calibration

收稿日期: 2014-11-07

中图分类号: V248.3

TP391

基金资助:吉林省重大科技攻关项目(No.11ZDGG001);总装预研基金资助项目(No.402040203);国家林业公益性行业科研专项基金资助项目(No.201204515)

作者简介: 周前飞(1989-),男,湖南邵阳人,博士研究生,2011年于中国地质大学(武汉)获得学士学位,主要从事航空光电成像畸变校正技术方面的研究。E-mail:wgzqfei@163.com

引用本文:

周前飞, 刘晶红, 王宣, 孙明超. 航空变焦距斜视成像几何畸变的自动校正[J]. 光学精密工程, 2015, 23(10): 2927-2942. ZHOU Qian-fei, LIU Jing-hong, WANG Xuan, SUN Ming-chao. Automatic correction of geometric distortion in aerial zoom squint imaging. Editorial Office of Optics and Precision Engineering, 2015, 23(10): 2927-2942.

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