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飞行器姿态对CMOS航空相机成像的影响

万磊[1,2], 贾平[1*], 张叶[1], 修吉宏[1]

1. 中国科学院 长春光学精密机械与物理研究所, 吉林 长春, 130033;
2. 中国科学院大学, 北京 100049

Effect of aircraft attitude on imaging of CMOS aerial cameras

WAN Lei[1,2], JIA Ping[1*], ZHANG Ye[1], XIU Ji-hong[1]

1. 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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摘要 为了消除CMOS航空相机高速成像时存在的卷帘快门(RS)效应对成像质量的影响,建立了在任意姿态角下计算CMOS相机RS效应的数学模型。通过分析CMOS成像原理,利用坐标变换法求得像面上任意像素点的速度。在分析卷帘快门原理的基础上推导出了RS效应的解析式。利用蒙特卡洛统计方法分析模型精度,对模型关键参数进行了仿真实验,并讨论了帧间延迟和姿态角对RS效应的影响。实验结果显示:在高度测量误差小于0.09 km,速度测量误差小于0.3 km/h,姿态角测量误差小于0.02°时,该模型的精度在1/3个像元以内。得到的结果证明了本文模型的有效性。该模型可作为定量分析大面阵CMOS相机RS效应的理论依据,对CMOS传感器在航空相机领域的应用有指导作用。

关键词 : CMOS航空相机, 成像系统, 卷帘快门(RS)效应, 误差分析, 飞行器姿态, 姿态角

Abstract : To eliminate the influence of Rolling Shutter(RS) on imaging quality in higher speed imaging by a CMOS (Complementary Metal-Oxide Semiconductor) aerial camera, a mathematical model to calculate the RS effect at arbitrary gesture angles was built . The CMOS imaging principle was analyzed, and each pixel velocity of CMOS array was derived from coordinate transformations. After analysis of the working principle of the RS, the analytical equation of the RS effect was deduced. The Monte Carlo statistical method was used to analyze the model accuracy, the key parameters of the model was simulated and the influence of key parameters including interframe delay and gesture angles on the RS distortion were discussed. The experimental results indicate that when the measuring errors of height,speed and the gesture angles are less than 0.09 km, 0.3 km, and 0.02°, respectively, the calculation error of this model is less than 1/3 pixel. These results demonstrate the effectiveness of the model. It concludes that this model can be the theoretical foundation of quantitatively analyzing RS effect of large frame CMOS aerial cameras and can offer some theoretic guidances for applying CMOS in the field of aerial cameras.

Key words : CMOS aerial camera imaging system Rolling Shutter(RS) effect error analysis aircraft attitude gesture angle

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作者简介: 万磊(1988-),男,湖北天门人,博士研究生,2007年于中国科技大学获得学士学位,主要从事航空CMOS成像方面的研究。E-mail:keshawanshi@163.com

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