[an error occurred while processing this directive]

光学精密工程 2012, 20(12) 2812-2820 ISSN: 1004-924X CN: 22-1198/TH

信息科学

姿态对地指向不断变化成像时的像移速度计算

黄群东, 杨芳, 赵键

航天东方红卫星有限公司,北京 100094

摘要： 基于线阵时间延迟积分(TDI)CCD推扫成像原理,分析了敏捷卫星在三轴姿态机动过程中动态成像的像移问题。由于姿态对地指向不断改变会导致像面空间方位不断改变,从而造成像移速度的改变,本文通过坐标变换法推导出了动态成像方式下的像移速度数学解析表达式,仿真得到了不同姿态机动角速度情况下的TDICCD积分时间数量级。数值仿真分析表明:当前50 μs级的航天相机在700 km的轨道高度可以实现以0.5(°)/s角速度上限进行动态推扫成像;当姿态机动角速度大于0.5(°)/s时,曝光时间越来越短,需要设计更高水平的相机。以上结论表明,对于不同角速度的动态成像任务,需要量化TDICCD积分时间数量级,实现在三轴姿态机动过程中开启光学有效载荷来完成推扫成像的动态成像。

关键词： 敏捷成像 TDI-CCD相机 像移 积分时间 像移速度 动态成像

Calculation of image motion velocity for agile satellite dynamic imaging to changed continuously attitude point

HUANG Qun-dong, YANG Fang, ZHAO Jiang

DFH Satellite Co., Ltd, Beijing 100094, China

Abstract: According to the principle of push-broom imaging of a linear array Time Delay Integration(TDI) CCD, the image motion in dynamic imaging of a agile satellite is analyzed in three-axis attitude maneuvering. As the changed continuously attitude points to the earth can change the spatial orientation and result in a changed image motion velocity, the image quality and image resolution will be deteriorated. To decrease the influence of attitude change on image quality, this article uses the coordinate transformation to acquire the mathematical expression of the image motion velocity in dynamic imaging, and obtains the variety of the image motion velocity in simulation analysis to quantify the magnitude of the integration time. Numerical simulation shows that the current level of space camera can achieve the max angular velocity limit dynamic push-broom imaging of 0.5(°)/s on an orbit height of 700 km. When the attitude maneuvering angular velocity is greater than 0.5(°)/s,it needs to design a high level camera because the exposure time is shorter and shorter. Based on the above conclusion, it suggests that the magnitude of integration time for TDI CCD TDI) should be quantified for dynamic imaging at different angle speeds, and only in this way can the push-broom dynamic imaging be implemented in three-axis attitude maneuvering.

Keywords: agile imaging Time Delay Integration(TDI)-CCD camera image motion integration time image motion velocity dynamic imaging

收稿日期 2012-08-27 修回日期 2012-09-28 网络版发布日期

基金项目:

航天东方红卫星有限公司自主研发课题资助项目(No.025YF-Z-01)

通讯作者: 黄群东

作者简介: 黄群东 (1986-),男,福建莆田人,助理工程师,2008年于南京航空航天大学获得学士学位,2012年于中国空间技术研究院获得硕士学位,主要从事航天器总体设计、卫星姿控总体设计的研究。E-mail:bingdong168@163.com.cn
作者Email: bingdong168@163.com

参考文献:

[1] HUANG Q L, LI X M. Application of TDICCD on real-time earth reconnaissance satellite *//Proc. Of SPIE, Automated Optical Inspection for Industry: Theory, Technology and Applications Ⅱ (3558) Washington*, 1998:93-104. [2] 黄群东, 杨芳, 赵键. 敏捷成像速度失配时的偏流角计算及姿态补偿. 2011年先进航天控制技术发展学术会议,黄山,2011:136-144. HUANG Q D, YANG F, ZHAO J. Calculation and attitude compensation for the drift angle caused by the agile imaging and the velocity mismatch. *2011, The Development Of Advanced Space Control Technologies Conference,Huangshan*,2011:136-144.(in Chinese) [3] 王家骐, 于平, 颜昌翔, 等. 航天光学遥感器像移速度矢计算数学模型[J]. 光学学报, 2004,24(12):1585-1589. WANG J Q, YU P, YAN C X, *et al.*. Space optical remote sensor image motion velocity vector computational modeling[J]. *Acta Optica Sinica*, 2004,24(12):1585-1589.(in Chinese) [4] 颜昌翔, 王家骐. 航相机像移补偿计算的坐标变换方法[J]. 光学精密工程, 2006,14(3):203-207. YAN C X, WANG J Q. Method of coordinate transformation for IM&IMC calculation in aerospace camera system[J]. *Opt. Precision Eng.*, 2006,14(3):203-207.(in Chinese) [5] 王运, 颜昌翔. 基于差分法的空间相机像移速度矢量计算[J]. 光学精密工程, 2011,19(5):1054-1060. WANG Y, YAN C X. Computation of image motion velocity vector for space camera based on difference method[J].*Opt. Precision Eng.*, 2011,19(5):1054-1060.(in Chinese) [6] 闫得杰, 韩诚山, 李伟雄. 飞行器侧摆和前后摆及控制误差的优化设计[J]. 光学精密工程, 2009,17(9):2224-2229. YAN D J, HAN C S, LI W H. Optimization design of scroll and pitch and their control errors on aerocraft [J]. *Opt. Precision Eng.*, 2009,17(9):2224-2229.(in Chinese) [7] 闫得杰, 徐抒岩, 韩诚山. 飞行器姿态对空间相机像移补偿的影响[J]. 光学精密工程, 2008,16(11):2199-2203. YAN D J, XU S Y, HAN C S. Effect of aerocraft attitude on image motion compensation of space camera [J]. *Opt. Precision Eng.*, 2008,16(11):2199-

2203.(in Chinese) [8] JEAN J, ERIC J, G RARD L, *et al*.. Attitude guidance technics developed in CNES for earth observation and scientific missions. *The 28th Annual AAS Guidance and Control Conference, Breckenridge*,2005:11-16. [9] PERRET L, BOUSSARIE E, LACHIVER J M, *et al*.. The Pléiades system high resolution optical satellite and its performances. *The 53rd International Astronautical Congress The World Space Congress, Houston*,2002. [10] 刘一武，张军. 敏捷卫星快速姿态机动控制方法研究. 全国第十三届空间及运动体控制技术学术年会论文集，宜昌，2008:1-6. LIU Y W, ZHANG J. Agile satellite fast attitude maneuver control method research. *The Thirteenth National Conference On Space And Motion Control Technology Conference, Yichang*, 2008:1-6.(in Chinese) [11] 樊超，李英才，易红伟. 速高比对TDICCD相机的影响分析[J]. 兵工学报，2007,28(7):817-821. FAN C, LI Y C, YI H W. Influence of Velocity-Height ratio of satellite on the TDICCD camera[J]. *Acta Armamentarii*, 2007,28(7):817-821.(in Chinese) [12] MILLER B M, RUBINOVICH E Y. Image motion compensation at charge-coupled device photographing in delay Integration mode [J]. *Automation and Remote Control*, 2007, 68(3):564-571. [13] OLSON G. Image motion compensation with frame transfer CCD's [J]. *SPIE*, 2002,4567:153-160. [14] SMITH S L,TANTALO J M. Understanding image quality losses due to smear in high-resolution remote sensing imaging system [J].*Opt Eng*,1999,38(5):821-826. [15] 翟林培，刘明，修吉宏. 考虑飞机姿态角时倾斜航空相机像移速度计算 [J]. 光学精密工程，2006, 14(3):490-494. ZHAI L P, LIU M, XIU J H. Calculation of image motion velocity considering airplane gesture angle in oblique aerial camera [J]. *Opt. Precision Eng.*, 2006, 14(3):490-494.(in Chinese) [16] DAMILANO P. Pleiades high resolution satellite: a solution for military and civilian needs in metric-class optical observation. *The 15th Annual/USU Conference on Small Satellites*, 2001. [17] 张林，吴晓琴，汤宫民. 基于MTF的时间延迟积分CCD成像系统同步误差分析 [J]. 应用光学，2006, 27(2):167-170. ZHANG L, WU X Q, TANG G M. Analysis of synchronization error for time delayed integration (TDI) CCD imaging system based on MTF[J]. *Journal of Applied Optics*, 2006, 27(2):167-170.(in Chinese)

本刊中的类似文章

1. 李伟雄，闫得杰，徐抒岩，胡君.空间相机地心距误差修正[J]. 光学精密工程，2012,20(5): 1126-1133
2. 李延伟，远国勤.面阵彩色航空遥感相机前向像移补偿机构精度分析[J]. 光学精密工程，2012,20(11): 2439-2443
3. 孙辉，张淑梅.机载成像系统像移计算模型与误差分析[J]. 光学精密工程，2012,20(11): 2492-2499
4. 武星星，刘金国.应用地球椭球的三线阵立体测绘相机像移补偿[J]. 光学精密工程，2011,19(8): 1794-1800
5. 王运，颜昌翔.基于差分法计算空间相机的像移速度矢量[J]. 光学精密工程，2011,19(5): 1054-1060
6. 黄浦，葛文奇，李友一，李军，修吉宏.航空相机前向像移补偿的线性自抗扰控制[J]. 光学精密工程，2011,19(4): 812-819
7. 张刘，孙志远，金光.星载TDICCD动态成像全物理仿真系统设计[J]. 光学精密工程，2011,19(3): 641-650
8. 马天波，郭永飞，李云飞.科学级TDICCD相机的行频精度[J]. 光学精密工程，2010,18(9): 2028-2035
9. 闫得杰.飞行器侧摆和前后摆对空间相机成像质量的影响[J]. 光学精密工程，2009,17(9): 2224-2229
10. 孔德柱.基于DSP的空间相机像移速度计算的研究[J]. 光学精密工程，2009,17(8): 1935-1941
11. 徐抒岩,于涛,韩诚山,李杨,王永成.一种空间相机偏流角间歇式实时调整方法[J]. 光学精密工程，2009,17(8): 1908-1914
12. 李正刚,吴一辉,宣明,王一凡.一种利用统一积分时间数据提高生化分析仪采集精度的方法[J]. 光学精密工程，2009,17(5): 980-984
13. 李仕.一种航空斜视成像异速像移实时恢复算法[J]. 光学精密工程，2009,17(4): 895-900
14. 谷松，王绍举.空间相机调偏流机构的设计与控制[J]. 光学精密工程，2009,17(3): 615-620
15. 田园,韩昌元,张晓辉.胶片摄影空间相机动态成像质量评价[J]. 光学精密工程，2008,16(2): 190-196