

摘要: 考虑推扫式遥感相机中的时间延迟积分(TDI) CCD行周期误差对成像动态调制传递函数(MTF)影响较大, 且积分级数越高影响越大, 本文分析并推导了存在行周期误差时TDICCD推扫成像的动态MTF数学模型并进行了仿真验证。首先, 介绍了典型的TDICCD的电荷行转移时序, 分析并推导了该时序下的单级和多级积分级数时的采样窗口函数以及该时序下TDICCD的行周期误差率与动态MTF之间的精确函数关系, 并指出本文推导的精确函数比传统函数多一个非线性参量。然后, 进行了仿真实验。结果表明: 行周期误差率 $\Delta T/T=0$ 时, 该时序下的TDICCD在Nyquist频率下的动态MTF为静态MTF的0.632 5倍(TDICCD相数 $b=4$), 显示得到的动态MTF与行周期误差率关系曲线较传统方法得到的曲线有明显差异且动态MTF值要高于后者。最后, 给出了在不同积分级数下、5%动态MTF下降率指标要求时的行周期误差率最大容许值。

关键词: 遥感相机 时间延迟积分CCD 行周期误差 动态MTF

Relation of line transfer period error and dynamic MTF of TDI CCD in remote sensing camera

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Abstract: As the error of line transfer frequency from Time Delay Integration(TDI)CCD has strong influence on dynamic Modulation Transform Function(MTF), and it is stronger when the integral grade is higher, an accurate mathematical model for dynamic MTF and line transfer period error rate was developed. Firstly, a typical line transfer timing of TDICCD was introduced and the window functions of one integral grade and multiple integral grade were derived. On these bases, the relationship between line transfer period error rate and dynamic MTF for this timing was established by Fourier transform of the window functions is pointed out that there is a nonlinear parameter in the function while there is none in the traditional one. Then, simulations and experiments were performed, which indicate that when $\Delta T/T=0$, the dynamic MTF value for this timing is 0.632 5 times of static MTF with the number of phases $b=4$. It also indicates that, there are obvious differences between dynamic MTF curves from proposed method and traditional method. Finally According to the requirement of the index, the maximum line transfer period error rates with different integral grades are given, which ensures that the decline of the dynamic MTF is less than 5%.

Keywords: remote sensing camera Time Delay and Integration CCD line transfer period error dynamic Modulation Transform Function(MTF)

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参考文献:

- [1]姚呈康, 李庆辉, 胡琳. 星载遥感相机像移分析[J]. 红外与激光工程, 2009, 38(5):901-904. YAO CH K, LI Q H, HU L. Analysis of image motion of satellite remote sensing camera [J]. Infrared and Laser Engineering, 2009, 38(5): 901-904. (in Chinese) [2]王雪晶, 张健, 魏仲慧, 等. 基于遥感相机模型的遥感图像彩色校正[J]. 红外与毫米波学报, 2002, 21(6):443-446. WANG X J, ZHANG J, WEI ZH H, et al.. Color correction for remote sensing images based on remote sensing camera model [J]. J. Infrared Millim. Waves, 2002, 21(6): 443-446. (in Chinese) [3]韩昌元. 高分辨力空间相机的光学系统研究[J]. 光学 精密工程, 2008, 16(11):2164-2172. HAN CH Y. Study on optical system of high resolution space camera [J]. Opt. Precision Eng., 2008, 16(11):2164-2172. (in Chinese) [4]郑耿峰, 张柯, 韩双丽, 等. 空间TDICCD相机动态成像地面检测系统的设计[J]. 光学 精密工程, 2010, 18(3):623-629. ZHENG G F, ZHANG K, HAN SH L, et al.. Design of test system for motion images of space TDICCD camera [J]. Opt. Precision Eng., 2010, 18(3):623-629. (in Chinese) [5]闫得杰, 徐打岩, 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 SH Y, HAN CH SH. Effect of aircraft attitude on image motion compensation of space camera[J]. Opt. Precision Eng., 2008, 16(11)2199-2203. (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 CH SH, LI W X. Optimization design of scroll and pitch and their control errors on aircraft [J]. Opt. Precision Eng., 2009, 17(9)2224-2229. (in Chinese) [7]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. MA T B, GUO Y F, LI Y F. Precision of row frequency of scientific grade TDICCD camera [J]. Opt. Precision Eng., 2010, 18(9):2028-

2035. (in Chinese) [8]龙夫年, 张旺, 刘剑峰. 卫星姿态精度对TDICCD相机的影响[J]. 哈尔滨工业大学学报, 2002,34(3): 382-384.
LONG F N, ZHANG W, LIU J F. Effect of satellite attitude control accuracy on TDI CCD cameras [J]. Journal of Harbin Institute of Technology, 2002,34(3): 382-384. (in Chinese) [9]胡永力, 谭南征. TDICCD相机侧摆MTF的研究[J]. 航天返回与遥感, 2003,24(1): 33-37. HU Y L, TAN N ZH. Study On Scroll MTF of TDICCD Camera [J]. Spacecraft Recovery & Remote Sensing, 2003,24(1): 33-37. (in Chinese) [10]WANG D J,ZHANG T,KUANG H P. Clocking smear analysis and reduction for multi phase TDI CCD in remote sensing system [J]. Optics Express, 2011,19(5): 4868-4880.

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1. 刘春香 郭永飞 李宁 司国良 李云飞. 星上多通道遥感图像的实时合成压缩[J]. 光学精密工程, 2013,21(2): 445-453
2. 魏新国 王清龙 李健 赫华颖. 星敏感器和遥感相机主光轴交联角的在轨检校[J]. 光学精密工程, 2013,21(2): 274-280
3. 夏巧桥 汪鼎文 张立国 吴敏渊 陈曦. 高速多通道遥感相机快视系统的实现[J]. 光学精密工程, 2013,21(1): 158-166
4. 卢振华, 郭永飞, 李云飞, 吕恒毅. 利用CCD拼接实现推扫式遥感相机的自动调焦[J]. 光学精密工程, 2012,20(7): 1559-1565
5. 吕恒毅, 刘杨, 郭永飞. 遥感相机焦面CCD机械拼接中重叠像元数的确定[J]. 光学精密工程, 2012,20(5): 1041-1047