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空间相机图像复原的实时处理

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Real-time processing of image restoration for space camera

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摘要 提出了一种基于有效提取点扩散函数(PSF)的图像实时复原方法来提高空间相机成像性能。从典型的图像复原原理出发, 分析了实时复原的关键问题。将PSF与典型的线性复原滤波方法相结合计算出实时复原的反卷积算子, 通过空间域卷积计算的方式进行实时复原, 并以现场可编程门阵列(FPGA)为核心器件设计了具备图像实时复原计算性能的硬件系统。利用上述设计在硬件平台上对空间相机的遥感图像数据进行了实验验证, 并与经典图像复原方法的效果进行了对比。结果显示, 采用该平台对单片CCD像元数为12 000的空间相机图像进行复原后, 灰度平均梯度由3.788 7提升到8.229 6, 拉普拉斯和由15.456 7提升到43.907 5, 达到了经典图像复原的性能。在模板尺寸为19 pixel×19 pixel时, 实时复原处理延时为1.9 ms, 复原后的相机调制传递函数在Nyqyist频率处从0.1提高到0.23, 有效地提高了空间相机系统的成像性能。

关键词 : 空间相机, 图像实时复原, 反卷积算子, 现场可编程门阵列

Abstract : To enhance the imaging performance for a space camera, a real-time image restoration method was proposed based on the efficient extraction of Point Spread Function (PSF). The key issues of real-time image restoration were analyzed based on typical image restoration methods. A deconvolution operator was given by combining the PSF with the typical image restoration methods. Then, the real-time recovery processing was carried out in a spatial domain by using a Field Programming Gate Array(FPGA) as the core device. The verified experiments on the remote sensing image data from the space camera were performed on a hardware platform and the restoration results by proposed method were compared with those by typical image restoration methods. The comparative results show that the gray mean gradient of the image from one space camera with 12 000 pixel CCD chip has improved from 3.7887 to 8.2296 and the Laplacian from 15.4567 to 43.9075, which achieves the same performance as that of the typical image restoration methods. The image processing delay is 1.9 ms when the deconvolution operator size is 19 pixel×19 pixel, and the Modulation Transfer Function(MTF) is increased from 0.1 to 0.23 at the Nyqyist frequency. These data demonstrate that the imaging performance within the whole space camera system is significantly improved by the real-time image restoration system.

Key words : space camera real-time image restoration deconvolution operator Field Programmable Gate Array(FPGA)

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