ESTIMATION OF THE MTF OF A SATELLITE IMAGING-SYSTEM FROM CELESTIAL SCENES

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1. INTRODUCTION

Electro-optical Remote Sensing Satellites provide imagery of the earth surface. To assess the quality of the images of such system, the camera is tested prior to launch, and evaluation and monitoring of the complete system performance are required while the satellite is in orbit. The objective of this work is to propose a method to measure and evaluate the performance of the camera on board of a commercial satellite.

A common index of performance of electro-optical imagers is the Modulation Transfer Function (MTF). In the past, the MTF was mostly evaluated in one dimension, either in the scan direction (the direction in which the ground trace of the sensor is advanced), or in the direction perpendicular to scan (the so called mux direction). In this work, the MTF is evaluated simultaneously in both directions using celestial objects as point sources.

The advantages of celestial scenes over terrestrial sites are that they are ideal point light source (ideal source for exciting the Point-Spread-Function), there are hardly any atmospheric effects on the images taken, the celestial scenes are accessible on every pass, and the only task required is that of aiming the satellite camera toward space. In this work, analysis of celestial scenes which were scanned by the satellite ErosB during the year of 2007 is presented.

The ErosB satellite (Figure 1), is a high performance, low cost, light weight, highly maneuverable high-resolution observation satellites. The camera on board uses a line detector of CCD/TDI type (Charge Coupled Device/Time Delay Integration), and it has a standard panchromatic resolution of 0.70 m at an altitude of about 500 km [1].

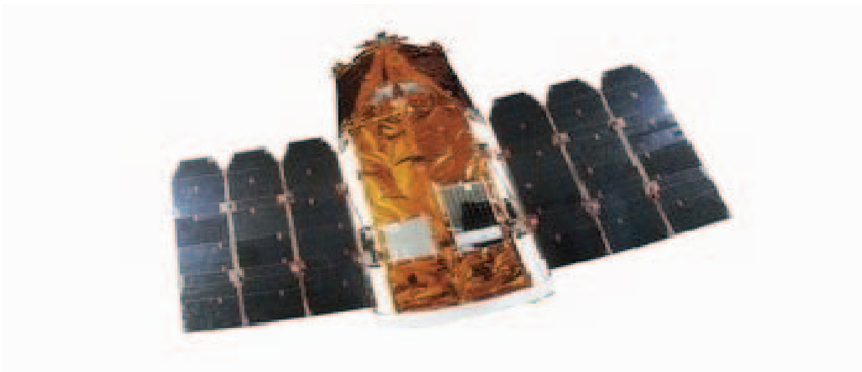

Figure 1 Eros-B Satellite

2. METHODOLOGY

A star is an ideal point source as its angular extent is much smaller than the pixel's IFOV, thus its image is the system PSF from which the MTF can be calculated.

The image of a star imaged by ErosB is shown in figure 2. The image is sparsely sampled by the detector, and is asymmetric due to random location with respect to the pixel grid and due to optical aberrations.

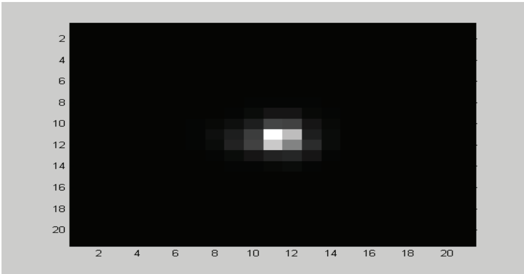

Figure 2: The image of a star imaged by the ErosB satellite

To arrive at a properly sampled star image we use several star images and take advantage of their random position with respect to the grid of pixels, thereby to rebuild an over sampled PSF from which the MTF can be computed without undesirable aliasing effect [2].

3. ALGORITHM DESCRIPTION

The algorithm developed to arrive at a properly sampled PSF from a multitude of under sampled star images comprises several steps which are presented here:

First step: A two-dimensional Gaussian model is fitted to each star image [3].

Second step: All images are aligned to a common origin, in sub pixel resolution (e.g. 1/10 pixel), according to the center of mass of every Gaussian model (as fitted in the first step).

Third step: The resized and relocated samples of each image are spline interpolated to generate new data points in the above subpixel resolution.

Fourth step: All stars are normalized to the same height and, accordingly, the values of the sampled point of each image are resized

Fifth step: Compute the average of all value for each point of the subpixel grid. The results of the fifth step are the properly sampled PSF.

4. CONCLUSIONS

Celestial scenes were obtained by ErosB during the year 2007. By following the MTF estimation through time, this method was proven to be a reliable and consistent method to monitor the imaging system performance.

5. REFERENCES

[1] ImageSat International (ISI), http://www.imagesatintl.com

[2] Dominique Leger, Francoise Viallefont, Emmanuel Hillairet and Aime Meygret, "In-flight refocusing and MTF assessment of SPOT5 HRG and HRS cameras", 9th International Symposium on Remote sensing, Aghia Pelagia (Greece), September 2002.

[3] Manjunath Kempaiah Rangaswamy, "QuickBird2, Two-dimensional On-orbit Modulation Transfer Function Analysis using Convex Mirror Array" (thesis work, south-dakota-state university 2002).