

ON-ORBIT MODULATION TRANSFER FUNCTION ESTIMATION USING GROUND TARGETS

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ABSTRACT :

During the last few decades, imagery from orbiting satellite sensors has provided much information about the Earth surface and the effects of the human activities upon it. For this information to be useful, it must that any artefacts present in the data be corrected. As blur of the image due to the behaviour of the embedded sensors. During the acquisition process, the imaging system causes image degradations due to the cumulative effects of the instrumental optics (diffraction, aberrations, focusing error) and image motion induced by the satellite movement. Satellite images can be corrupted by an optical blur and electronic noise. Blurring is modelled by convolution with a known linear operator and the noise is supposed to be additive white and Gaussian with a known variance. So the deconvolution of a blurred and noisy image is an ill-posed problem and therefore must be regularized. Typically, the degradation can be modelled by linear system characterized by its Point Spread Function (PSF) or by its Modulation Transfer Function (MTF) in the frequency domain. The point spread function (PSF) of a given image acquisition system measure how the optical system spreads the image of a point, and it enables an objective assessment of the imaging system. MTF Blind estimation is done without any a priori on the original image or in the way in which it was acquired. The goal is to estimate the imager spread function and then to deblur the image recorded to lead to the real image. Historically, MTF has been estimated using image features that represent edge or sinusoidal signals as inputs. We met a multitude of methods and concepts. Basically, there exist three ways to determinate the PSF. The first one uses images targets that must have well defined shape and size as airport runway, bridges. The second method utilizes images acquired by higher resolution sensor, which are low-pass filtered and compared with the image under study for a simulation. The third one uses the system design specifications and the system analytic model of image features that represent edge or sinusoidal signals as inputs. Choice among these methods strongly depends on intrinsic characteristics (orbit, resolution, etc...) of both imagers and host satellites. During sensor commissioning the system MTF is compared against the design requirements to verify expected performance is achieved. For the end user system MTF can be used to compare the intrinsic quality of imagery from various sources as well as analytically equalizes the sharpness of multiple images from different sensors in a combined product. Our goal through this work is to perform on-orbit estimation of the MTF of the imager's of Alsat -1, first Algerian satellite. Which is a high performance camera system designed to provide medium resolution, high dynamic range and low noise imagery from orbit. The Camera is of the push broom type, whereby the side scan is performed electronically at the focal plane array and the forward scan is provided by the motion of the spacecraft. The 32 meters GSD Camera head contains the Focal Plane Array, a linear KLI -10203 CCD from Kodak. This sensor is a high resolution, tri-linear array designed for high-resolution colour scanning applications. Each device contains 3 rows of 10200 active photo elements, consisting of high performance 'pinned diodes' for improved sensitivity, lower noise and the elimination of lag. A sensor provides for each colour a separate electronic exposure control to achieve system colour balance. On the other hand, pre-flight test and measurements has been performed using optical integrating sphere. The six Alsat -1 spectral channels were exposed to a specified light source by varying system gain and exposure time. The data set collected were of a great utility to correct some artefacts like vertical striping or vignetting. However, because of the rigors of harsh space environment, the pre-flight tests become obsolete. Therefore, on-orbit quantification of MTF must be done. In this study we choose a method which primarily consists to estimate the MTF parameters of satellite camera from a single satellite image. We inspire from J.C Storey works about the estimation of the modulation transfer function of Landsat satellite. As it impossible to use a sinusoidal function to measure the MTF and as it is impossible to inject an pulse signal in the satellite embedded imager, the solution is to reproduce effect of a impulse signal to the input of the imager and to collect the signal at the exit and to deduce the MTF from them. To this end we have uses the Alsat -1 images of revealing sites like those of bridges to have an abrupt effect between black pixels and luminous pixels from where creation of the effect of signal impulse which we seek. Meanwhile we approximate imaging system point spread function as a Gaussian function. We will target the ground objects like Pontchartrain Lake Causeway in Louisiana and San Francisco Bay Bridge (United States). The MTF is calculated for both edge and bridge objects with a reasonable repeatability to the ground measurements. Having obtained the modulation transfer function for each of the three Alsat -1 channels, we hope then to use them for a systematic correction of the images by a simple reduction in the spectral field. This in-progress work is an attempt to measure the on orbit modulation transfer function for medium spatial resolution imaging satellites using sharp edges and pulses as ground inputs. We know that other MTF in-flight measurements methods were used for satellites similar to Alsat -1. Like those using artificial tarp targets and points sources (mirrors). As future work we hope to adapt and test these interesting methods for a validation of our approach as well as a more precise estimate of the MTF.