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Observing Mercury with the High Resolution Imaging Channel of SIMBIO-SYS

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Abstract

The High Resolution Imaging Channel (HRIC) of SIMBIO-SYS [1] is the visible imaging camera of the BepiColombo mission to Mercury. Its primary objective is to perform a detailed characterization of the Hermean surface geological units. In addition, HRIC observations will contribute, together with the radio-science experiment [2], in the determination of Mercury orbital parameters (e.g., obliquity, libration amplitude). For the correct scientific interpretation of HRIC data it is of paramount importance to correctly model all the instrument characteristics (e.g., MTF, optical aberrations, geometrical distortions, noises, compression) and to define an appropriate data reduction plan. This is the case of the HRIC Instrument Simulator which is capable to reproduce all the instrument degradation effects and, then, to apply a data reduction procedure to recover the original data.

1. Introduction

HRIC is based on a catadioptric Ritchey-Chretien design (with F/9.8) in a telecentric configuration with 41% obscuration ratio [3]. The channel IFOV of 2.5”/px allows to perform observations with 5 m/px from 400 km altitude; in addition, the selected 4Mpx Hybrid Si-PIN CMOS sensor guarantees a FoV of 1.47° which is compatible with continuous coverage in longitude. Spectral investigation is performed using a panchromatic filter (centred at 650 nm with 500 nm bandwidth) and three broad band filters (centred at 550, 750 and 880 nm with 40 nm bandwidth each).

2. HRIC Instrument Simulator

HRIC Instrument Simulator is an interactive extension of the instrument radiometric model [4] that operates on images giving a visual and quantitative estimation on the quality of the observations with respect to instrument characteristics.

2.1 Instrument modelling

Many degradation factors affect the quality of an image; they can be grouped as follows:

- Opto-mechanical design (i.e., optical MTF)

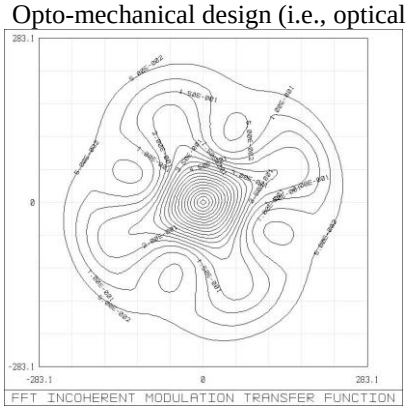

Figure 1: HRIC optical Modulation Transfer Function (MTF).

- Geometrical distortions (e.g., detector sampling, S/C and pointing random motion)

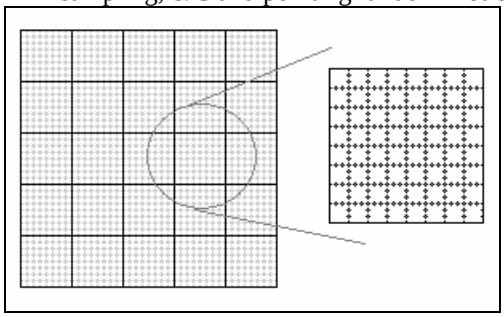

Figure 2: Image resolution reduction by HRIC pixel sensor sampling.

- Detector characteristics (e.g., readout noise, dark current, detector response non linearity)

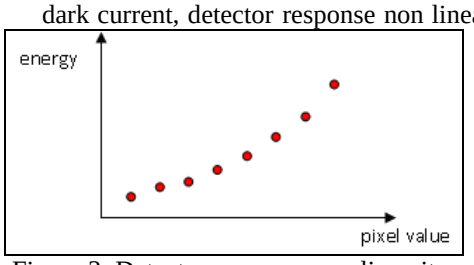

Figure 3: Detector response non linearity.

- Compression algorithm (e.g., wavelet compression efficiency [5])

Together with the above reported degradation sources, it must be considered the whole data reduction chain (e.g., noise subtraction, system MTF de-convolution) with relative residuals.

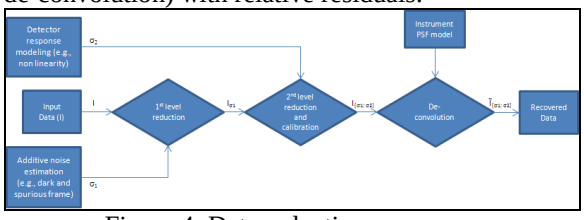

Figure 4: Data reduction sequence.

2.2 Simulation results

Some simulations have been performed with the HRIC Instrument Simulator both with synthetic (e.g., edges, multi-frequency bars) and realistic (e.g., Mars surface HiRISE images, Mercury surface MDIS images) scenarios.

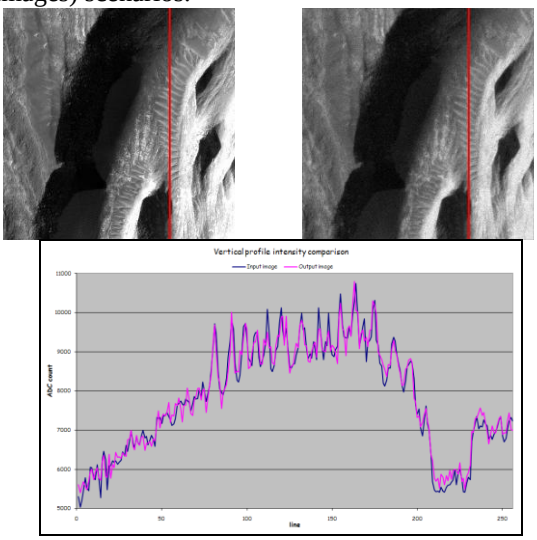

Figure 5: Comparison on a vertical profile between original and reconstructed image.

3. Conclusions

This work presents how the HRIC Instrument Simulator models each image degradation terms and which are the implemented data reduction techniques. The correct modelling of every degradation terms is of paramount importance in order to identify and plan observation strategies (e.g. instrument parameters settings, observation planning) and data reduction procedure (e.g., noise subtraction, PSF de-convolution) through the data calibration. Some preliminary results on imaging performances of the camera in terms of image quality and feature recognition capabilities are presented.

Acknowledgements

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References

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