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High-Precision Geometrically Corrected HiRISE Images

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Abstract

Geometric distortions due to spacecraft jitter on the High Resolution Imaging Science Experiment (HiRISE) can cause problems with stereo correlation, complicating terrain modeling and change detection studies. HiRISE has been operating in Mars orbit on the Mars Reconnaissance Orbiter (MRO) since 2006[1]. HiPrecision is a new image processing subsystem at the HiRISE Operations Center (HiROC). HiPrecision will remove distortions due to the optics and focal plane array, and if necessary, correct images for spacecraft jitter. The output of HiPrecision will be precision geometrically corrected images, plus updated camera pointing kernels (for jitter corrected images only). HiPrecision image and pointing kernel products will be made available to the public in the near future.

1. Introduction

HiRISE is a push broom type camera, acquiring images of the surface of Mars at a nominal pixel scale of up to 25 cm. The focal plane consists of a staggered array of 14 CCDs, 10 of which span the full swath width in a broad visible-near-IR bandpass (RED), and 4 of which add color in the visible blue-green (BG) and near infra-red (IR) bands, spanning the center ~20% of the image. Geometric distortions occur in HiRISE images due to high-frequency spacecraft jitter. These distortions, though generally not visible to the naked eye, can cause failures in stereo correlation software, resulting in poor terrain model quality. Jitter also complicates the BG/IR to RED color registration. Jitter is removed from HiRISE images using a method developed at HiROC to solve for the spacecraft jitter in a absolute sense [2], and image transformation programs implemented in the freely available Integrated Software for Imagers and Spectrometers, version 3 (ISIS3) (http://isis.astrogeology.usgs.gov). The HiPrecision image processing subsystem will be applied primarily to stereo images and seasonal repeat images for change detection, as this subset of HiRISE images requires this level of processing to be analyzed with the highest accuracy. Other images in the HiRISE catalogue could be processed by request.

2. HiPrecision

The HiPrecision subsystem consists of two branches (Fig. 1). The HiRISE Jitter-Analyzed CK (HiJACK) [2] branch is called if an image requires correction for jitter. The HiNoProj branch corrects only for optical and focal plane distortions. Inputs to either pipeline are radiometrically calibrated image data and spacecraft and camera pointing kernels (SPICE kernels). The output from either pipeline will be an image mosaic of the RED CCD images projected to ideal camera geometry. If the observation has been processed through HiJACK, the final mosaic will have jitter distortions removed. Additionally, two special pointing kernels (CKs) will be produced, one with the jitter motions modeled, and the other, "smoothed" kernel, to be used only with the HiJACKed image.

2.1 HiNoProj

The pipeline branch HiNoProj calls the ISIS3 program *noproj* to transform the individual CCD image pixels to ideal camera space for HiRISE geometry, based on calibration detailed in [3]. The HiRISE ideal camera is a single 20,000 sample line-scan camera with no optical distortion and centered on the HiRISE focal plane. Each of the 10 RED CCD sub-observations covers a segment of the 20,000 sample ideal camera. When the 10 ideal camera observations are mosaicked together, they form a single ideal camera observation.

2.2 HiJACK

Jitter information is gathered during the color registration process, which occurs before HiPrecision. During the initial stage of HiPrecision, the jitter measured in the color processing pipeline is analyzed. If the amplitude of the jitter is above a

certain threshold, the image is sent to HiJACK for correction. The first stage of the process is to measure the jitter at a higher frequency than in the color pipeline (which simply warps the BG and IR images to match the RED images) so that the absolute motion of the spacecraft during imaging can be derived. This step solves for the jitter function using Fourier analysis. The jitter measured from three overlapping CCD pairs are analyzed in frequency space, using the known time separation of each CCD pair. The derived spacecraft motion is then used to predict what the jitter would be for each of the input pairs of CCDs and compared to the actual input data to optimize the results. The output of this step is the input to the ISIS3 program *hijitter* which transforms the image pixels of each of the RED CCDs. *Hijitter* converts the pixel offsets into rotation angles and combines them with the reconstructed MRO pointing kernel quaternions in a way to avoid amplification of low frequency motions that may be described by both. The corrected camera pointing positions are then mapped to the HiRISE ideal camera with a smoothed CK to produce a distortion-free and jitter-free image.

2.3 SPICE Kernels

Images processed through HiJACK will also be accompanied by two pointing kernels: the jitter corrected kernel, and a smoothed kernel. The jitter corrected kernel is to be used for processing a HiRISE observation from the Engineering Data Record (EDR) stage through final map projection. This will remove jitter distortions from the image with the minimum of pixel transformations. The smoothed kernel should only be applied to the image output from HiJACK, as that image has already had the jitter removed.

3. Products and Availability

The output products of HiPrecision will be images and SPICE kernels. The image data from either branch of HiPrecision (HiNoProj or HiJACK) can be map projected if desired. They are also the input required for stereo DTM processing. Image data and SPICE kernels will be available through the HiRISE web site. Additionally, special SPICE kernels will be archived with NASA's Navigation and Ancillary Information Facility (NAIF) data node (http://naif.jpl.nasa.gov/naif/).

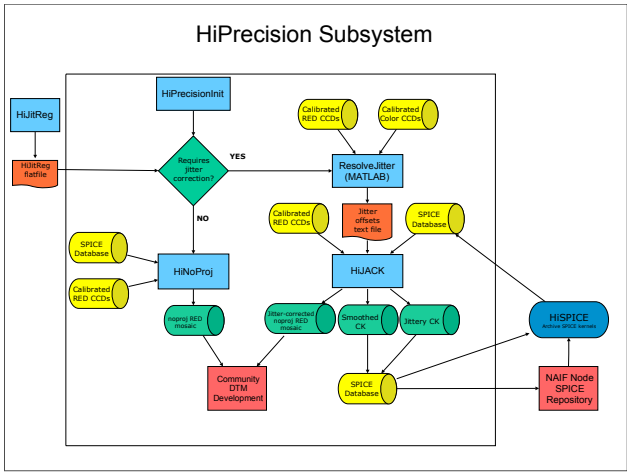

Figure 1: HiPrecision Subsystem flowchart. At the initiation of the pipeline, an observation is either sent through NoProj or HiJACK, depending on the need to correct for jitter.

6. Summary and Conclusions

The HiPrecision processing subsystem is in the final stages of development and testing at HiROC. HiPrecision will produce geometrically corrected HiRISE images with minimal jitter distortions, as well as special SPICE kernels. These data will be made available to the public via the HiRISE PDS data node (http://hirise.lpl.arizona.edu). While it is possible for anyone to generate these products with HiRISE images, the algorithms, source data and computational resources are not all publicly available outside the HiROC environment. It is hoped that with access to the HiPrecision products, a wider audience will have access to these data and will be able to utilize them for stereo analysis and change detection studies.

References

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