JunoCam Image Processing

Europlanet

Observatoire de la Côte d'Azur
Nice
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Raw Swath

Example: JNCE_2013282_00C102_V01 (EFB12)
Within one swath, all exposures consist of the same number of framelets.
All framelets within one swath are of the same width and height.
Usual Structure of an Exposure

Alternative 1: Three framelets

Alternative 2: One framelet

Alternative 3: One framelet, 2x2-binned

Images: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Example: Exposure of Three Framelets

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Mismatch Between Framelets

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Gap Between Framelets
Exposure Readout on the CCD

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
All Readout Regions on the CCD

Y-Positions of the readout regions retrieved from a post of M.Caplinger:

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Color Filters
Result: Colored Exposure
Next Colored Exposure

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Combine Channels of...
02 Colored Exposures
Combine Channels of ...
03 Colored Exposures

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Combine Channels of ...
04 Colored Exposures

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Combine Channels of ...
08 Colored Exposures

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Combine Channels of ...
14 Colored Exposures

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
Select a Region…
Zoom-In Reveals Mismatches

Image: NASA / JPL-Caltech / SwRI / MSSS / Gerald Eichstädt
One reason for mismatch: Geometry of image depends on rotation of camera.
Rotation-Invariant Spherical Coordinates

Associate camera pixel positions with respective 3-d pointing vectors. One reason for remaining mismatch: Translational motion of Juno.
“Time-variant“ reprojection varies simulated time with y like raw data; method is *locally* resilient w.r.t. small errors in shape model and trajectory. Consider **NAIF / SPICE** to estimate shape model and trajectory.
Some Dark Spots On the CCD

The few dark spots are at fixed pixel positions on the CCD. In swathes they show up as repetitive patterns.
Zoom-Out Contains Overlap Region

Overlap region combines framelets taken at different times.
Residual *global* errors in shape model and trajectory visible.
One reason for mismatch: Rotation of Planet.
Consider also TDI, small spacecraft nutation and model inaccuracies.
Include Rotation of Planet

Registering looks good. But colors are cast to reddish.
Moon as Color Calibration Target

Moon is visible in Earth fly-by image EFB01. Define Earth's moon as grey.
Calibrate Colors

Weight factors: red x 0.510, green x 0.630, blue x 1.0
Factors apply to square-root encoded raw images.
Global View of Time-Variant Reprojection

- Looks almost photorealistic.
- Slightly distorted, since perspective is continuously changing over y.
Reprojection for Start-Time

Southern hemisphere imaging started immediately after start-time. Then the camera pointed to outer space for more than 20 seconds.
Reprojection for Stop-Time

Northern hemisphere imaging ended immediately before stop-time. In the meanwhile Juno's vantage point moved.
Animation Using Two Consecutive Swathes

Simulation of a flight near Juno's actual trajectory.
Reprojection of consecutive images to same instant simplifies comparison.
Combining to a False-Color Image

The methane image is used to replace the green channel of the RGB image. Continents look greenish due to plants reflecting near infra-red.
Skipped

- Time Delay Integration (TDI)
- Flat field
- Hot pixels
- JPG/DCT compression
  - Linearization / Radiometric Factor
  - Stray light
  - Light leaks
- Energetic particles and camera degradation
  - Geometric in-flight calibration
  - Methane filter spectral properties
More High-Level Products

- Stereo images
- Map projections
- Merging several swathes
- Feature tracking
- Cloud-top topography
  - Wind fields
  - Radiation counting
  - Event detection (lightnings, impacts)
  - Superresolved products
  ...

Thank you for your attention!

Further reading:

*Junocam: Juno’s Outreach Camera*

C.J. Hansen·M.A. Caplinger·A. Ingersoll· M.A. Ravine·E. Jensen·S. Bolton·G. Orton

You may also be interested in following the links and discussions at [unmannedspaceflight.com](http://unmannedspaceflight.com)

Questions, Remarks?