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The Planet Pipeline: enabling data mining and citizen science with Hubble images of the Solar System

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Abstract

In 15 years of service, the Wide Field Planetary Camera 2 (WFPC2) onboard the Hubble Space Telescope (HST) obtained over 10,000 frames of Solar System data. Since standard data reduction pipelines are typically not optimized for moving-target data, our "planet pipeline" will uniformly reprocess and catalog this WFPC2 image collection to make it more immediately science-ready. Some of our processing steps will utilize citizen scientists to perform visual inspections. Our corresponding database will enable robust queries which are more specific to planetary science, helping archival researchers quickly find and utilize the prepared images within our collection for a wide range of scientific analyses. We welcome suggestions (especially from veteran WFPC2 users) on the optimal treatment and organization of this data collection, and also to identify a broad range of analyses that might only be possible with visual inspections by citizen scientists. Our processed images and associated catalogs will be made available as High Level Science Products (HLSP) in the Multimission Archive at STScI (MAST): http://archive.stsci.edu/prepds/planetpipeline

1. Data processing and meta-data

Our processing includes additional steps, beyond the basic calibrations performed by MAST, which are idiosyncratic enough that that they can be a barrier to faster and deeper analyses. Unlike fixed-target data, where rejection of artifacts is accomplished by combining multiple images, cleaning up moving target images requires an ability to distinguish real objects from artifacts in single images. For the initial rejection of bad pixels, cosmic rays, and star trails, we will use single-image rejection techniques based on Laplacian edge detection [3].

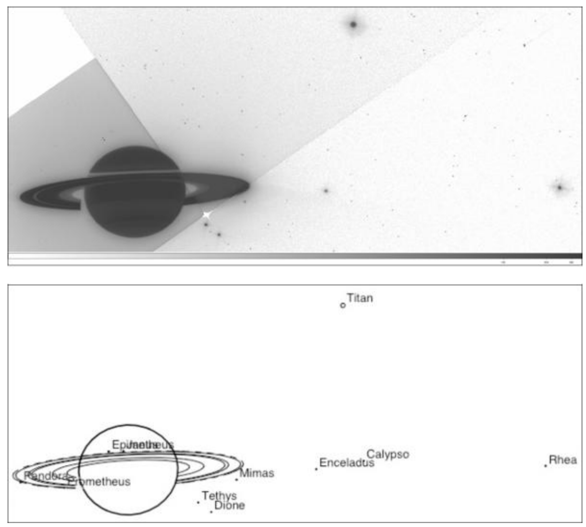

Figure 1: Drizzled WFPC2 mosaic of a Saturn observation (top), and corresponding satellite finder chart (bottom, from PDS Rings Node).

Then each image will be visually inspected to identify missed rejections of artifacts, and also unintentional rejections of real objects or features. The inspections will also record secondary and serendipitous features in each image, to form a comprehensive catalog. Finder charts will be used to verify which satellites were detected in each frame, and possibly reveal the presence of known or unknown asteroids or Kuiper belt objects (Figure 1). Planetary surface features such as storms, vortices, satellite umbrae, volcanoes, and craters can also be recorded. Each of the objects and features recorded will be assessed for data quality. Secondary objects have a higher probability of being somehow non-optimal: poorly placed, barely detected or over-exposed (saturated). So it is important to indicate which of these "extra" observations may be useless. Using our refined rejection masks, we will utilize all four WFPC2 chips to produce clean and undistorted mosaic images. We will optimally resample both Planetary Camera (PC) and Wide Field (WF) data by drizzling them to a common pixel scale, and apply image deconvolution methods wherever possible. We will insert planetary meta-data into our output image headers, since interpretation of solar system observations relies on time-variable properties such as observing geometry, solar orientation, etc. For each image, we obtain ephemeris data from the JPL Horizons website (http://ssd.jpl.nasa.gov/?horizons), associating the keywords in Table 1 with the image data. These keywords are then used to calculate the conversion between counts/sec in the image data into reflectivity, or I/F, following Sromovsky & Fry [2].

Table 1: Ephemeris meta-data stored for each image, gathered from the JPL Horizons website.

Horizons keyword	Description
1	Astrometric R.A. and DEC (J2000)
6	Satellite offset and PA from primary
10	Illuminated fraction
13	Target angular diameter
14	HST sub-longitude/latitude
15	Sun sub-longitude/latitude
17	North pole position angle & distance
19	Heliocentric range (and rate of change)
20	HST range (and rate of change)
21	One-way light time
24	Phase angle
26	HST-primary-target angle
39	Uncertainty in range and range rate

2. Database

We will create a database to relate the “input” archival data (identified by their unique rootnames) to all of our various High level Science Products (HLSP), and resolve some issues that make standard MAST queries of planetary data prone to incompleteness. Our web-accessible interface will allow robust queries which are more specific to planetary science, utilizing our standardized target names, meta-data, catalogs, and data quality ratings. Our database will allow archival researchers to mine this large data collection more effectively.

3. “Citizens, lend me your eyes”

Many moving-target image processing and analysis steps still rely on visual verification and acuity. Since our data set is large, the notion of manually inspecting every frame would have seemed prohibitive just a few years ago. But we can now leverage on the success of The Zooniverse (Galaxy Zoo, etc.) to engage citizen scientists in several of the tasks described above -- and we feel challenged to identify even more advanced eyeball-driven tasks. Our “Planet Investigators” (PlanetInvestigators.org) website will allow people to assist us in verifying our artifact rejections and assemble object catalogs [1]. It is now easily possible to have each image inspected multiple times, and set up iterative processes that can converge on the optimal output with greater confidence. Also, most Solar System objects fit on the higher-resolution Planetary Camera (PC), which means that the much larger adjacent Wide Field (WF) data was in many cases ignored, and may have never been inspected by human eyes. The possibility of citizens discovering Solar System objects in these often unexamined “bonus” fields is also tantalizing.

Beyond our initial data processing steps, we have further analytical steps in mind, which also rely on visual inspection by citizen scientists. For example, a deprojection (or mapping) tool would enable the tracking of storms and cloud features, and the creation of color composites of rotating targets. An aperture photometry tool would enable studies of satellite and small body phase curves and rotational light curves. But we also welcome suggestions on projects that could be done with our prepared data, via our Planet Investigators interface, which might only be possible with the engagement of an eager and growing population of citizen scientists.

Acknowledgement

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References

[1] Gay, P.L., et al., 2011, EPSC-DPS Meeting, Nantes

[2] Sromovsky, L.A., Fry, P.M., 2002, Icarus 157, 373–400

[3] van Dokkum, P.G., 2001, PASP 113, 1420–1427