NASA PDS IMG: Accessing Your Planetary Image Data. J. Padams[1], K. Grimes[1], G. Hollins[1], S. Lavoie[1], A. Stanboli[1], and K. Wagstaff[1]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA. (Jordan.H.Padams@jpl.nasa.gov)

Introduction: The Cartography and Imaging Sciences Node (IMG) of the NASA Planetary Data System (PDS) is the home to over 700 TB of digital image archives, making it one of the richest data repositories for planetary imagery in the world. Within these archives the data comes in many varieties, whether it's orbital versus landed missions, original raw experiment data versus derived products, differing coordinate systems, etc. Tools and services are needed to integrate these data so information can be correlated across missions, instruments, and data sets.

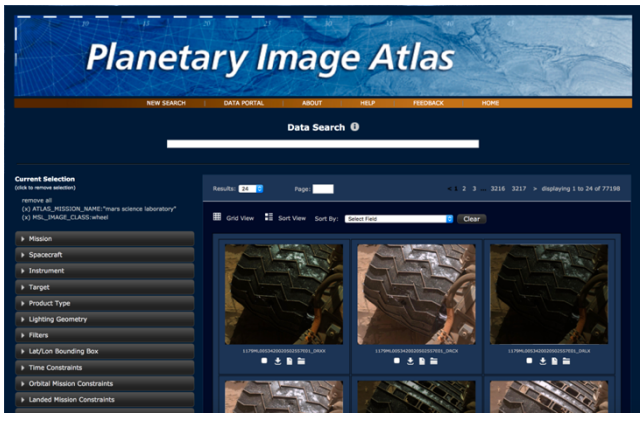
IMG has developed several tools and services to support both the wide variety of available data and the ease of access to the data both interactively, through a web browser, and programmatically through web services. From the scientist analyzing a particular crater on Mars by zooming in on a HiRISE image, to the software developer trying to build a tool to parse the metadata for all Mars Science Laboratory Hazard Camera images. The wide range of use cases provides us with a unique problem of providing interface usability for searching data, but also transparency into our backend service for software access. Leveraging partnerships with the Multimission Ground System and Service (MGSS) Office, Machine Learning and Instrument Autonomy Group (MLIA), and Multimission Image Processing Lab (MIPL) at the Jet Propulsion Laboratory (JPL) and the the expertise in planetary science, cartography, geodesy, photogrammetry and science software development at USGS Astrogeology Science Center, IMG continues to push towards new tools and services that bring the data to the people and support significant scientific discovery. For example, data archived and supported by IMG have been used to discover water on the "bone dry" Moon (Moon Mineralogy Mapper data; [1]), recent geologic activity related to CO_2 frost in martian gullies (High Resolution Imaging Science Experiment data or HiRISE; [2]), recent impacts on the Moon and Mars (Lunar Reconnaisance Orbiter Cameras or LROC; [3]; HiRISE; [4]), and recent lunar volcanism (LROC; [5]).

Atlas Web Interface: The Planetary Image Atlas (https://pds-imaging.jpl.nasa.gov/search/) provides access to the entire collection of IMG data through links to online holdings and data node catalogs [6]. The PDS Imaging Node Atlas utilizes faceted navigation, an interactive style of browsing datasets that allows users to filter a set of items by progressively selecting from only valid values of a faceted classification system. In the Atlas, facets are defined by the most commonly used search criteria for imaging datasets including but not limited to: mission name, instrument name, target, product type, lighting geometry meta-data (emission angle, incidence angle, phase angle), lat/lon meta-data, time constraints, etc. In addition to the faceted approach, the Atlas builds on the features of the previous Atlas including a map interface for the Saturnian moons, Earth's moon and Mars. The Atlas also incorporates the use of the MGSS webification backend that makes use of the image transformation software developed by MGSS (MIPL) through JavaScript widgets [7].

A recent, powerful enhancement to the Atlas is the ability to search for images based on the "content" in the image (i.e. crater, moon, rings). In order to detect content in the images, we developed software that leverages deep convolutional neural networks (CNN). "CNNs organize image content in increasingly complex representations starting at the pixel level up to entire objects, such as rings, craters, moons, and so on. Lower-level information, such as edges, corners, etc., are common to all content. The specifics of how the low-level information gets combined into high level representations is unique to the domain and requires training of the network with target content and associated labels." [8] Users can leverage this image content search to investigate particular craters on mars or study the wheel wear on the Mars Science Laboratory Curiosity rover [9].

Another recent enhancement of the Atlas is an improved Google-like search thats allows users the flexibility of simple search syntax with a refined result set, like 'mars crater' or 'cassini moon'. Users can then further narrow their search using the faceting features or additional text searches.

All the search capabilities of the Atlas, both new and old, help users across the globe find and download nearly 15 TB of data each month.



Atlas Search Service: The Atlas Web Interface displays query results returned from the Atlas Search Service (https://pds-imaging.jpl.nasa.gov/solr/pds_archives/search), a web service extending Apache Solr [10]. Harnessing the power of Solr, this web service provides fast search, JavaScript Object Notation (JSON) and eXtensible Markup Language (XML) return types for software parsing, and a refined query syntax for complicated searches. In addition, the PDS IMG Search Protocol was developed to provide simplified query access to the data through a REST-like API, as well as provide a means for integrated search across the PDS. As an extension of the PDS Engineering Node (PDS EN) Search Protocol [11], it heavily leverages the query parser syntax from Apache Lucene [12] as well as certain characteristics from the Planetary Data Access Protocol (PDAP) [11] developed by the International Planetary Data Alliance (IPDA). The protocol is intended for finding large sets of data, for example, searching by instrument, instrument-host, instrument-type, start-time, stop-time, etc. The PDS IMG Search Protocol (https://pds-imaging.jpl.nasa.gov/search/protocol) extends this by providing search against more imaging product-specific metadata, such as product-type, filter, image-content, orbit, planet-day, etc.

Webification (w10n): Webification (W10N) (https://pds-imaging.jpl.nasa.gov/tools/w10n/) is a specification that defines a common way to expose resources (composite files, databases, command-line applications, etc.) on the web.

The core idea is to make the inner components of resources directly addressable and accessible via well-defined and semantically meaningful URLs. The MGSS Web Resources Platform (WRP) provides a set of tools that leverage this specification to provide access to data and applications (services) through ReSTful URLs [13]. PDS IMG uses the Juneberry component of WRP to allow simple programmatic access to the data archive (https://pds-imaging.jpl.nasa.gov/w10n/), and Servicification (Serv10n) for access to backend services. This service is central to the server-side functionality for several IMG services, including the Planetary Image Atlas, PDS Marsviewer, and Landmarks Web Services.

References: [1] Pieters, C.M. et al., 2009, Science, v. 326, #5952, pp. 568-572. [2] Dundas, C.M. et al., 2012, Icarus 220, pp. 124-143. [3] Robinson, M.S. et al., 2015, Icarus 252, pp. 229-235. [4] Dundas, C.M. et al., 2014, JGR-P, 119, 109-127. [5] Braden, S. et al., 2014, Nature Geoscience, v. 7, 787-791. [6] Gaddis, L., et al., 2014, USGS Open-File Report 2014-1056, p. 197-199. [7] Stanboli, A. et al., 2015, Proceedings of the 2nd Planetary Data Workshop. [8] Altinok A. et al., 2017, Proceedings of the 3rd Planetary Data Workshop. [9] http://www.planetary.org/blogs/emily-lakdawalla/2014/08190630-curiosity-wheel-damage.html. [10] http://lucene.apache.org/solr/. [11] Hardman, S., et al., 2015, Proceedings of the 2nd Planetary Data Workshop. [12] https://lucene.apache.org/core/2_9_4/queryparsersyntax.html. [13] Grimes, K. et al., 2017, Proceedings of the 3rd Planetary Data Workshop.

Example Atlas Search Service URLs
Query for images of Mars
https://pds-imaging.jpl.nasa.gov/solr/pds_archives/search?target=mars
Query for images of Mars taken by Curiosity instruments
https://pds-imaging.jpl.nasa.gov/solr/pds_archives/search?target=mars&spacecraft=curiosity
Query for mosaics of Mars taken by Curiosity instruments
https://pds-imaging.jpl.nasa.gov/solr/pds_archives/search?target=mars&spacecraft=curiosity&product-type=mosaic

Example W10n URLs
To display metadata info, i.e., content of Cassini ISS data directory as JSON output
https://pds-imaging.jpl.nasa.gov/w10n/cassini/cassini_orbiter/coiss_2015/data/?output=json
Return meta info of image 0 in JSON. One attribute metadata contains VICAR labels
https://.../coiss_2015/data/1506288646_1506388236/N1506378403_1.IMG/0/
Returns image 0 in GIF format.
https://.../coiss_2015/data/1506288646_1506388236/N1506378403_1.IMG/0/image[]?output=gif
Return image 0 raster data array in JSON. Or in big/little-endian binary if output is set to big-endian or little-endian.
https://.../coiss_2015/data/1506288646_1506388236/N1506378403_1.IMG/0/raster/data[]?output=json