PROCESSING AND VISUALIZING PLANETARY DATA USING DAVINCI: UPDATES FOR PORTABILITY AND SCRIPTABLE EXECUTION. C. S. Edwards[1], S. Anwar[2], W. Hagee[2], D. Doerres[2], S. Dickensheid[2], P. R. Christensen[2], [1]US Geological Survey, Astrogeology Science Center, Flagstaff, Arizona, 86001, cedwards@usgs.gov, [2]Arizona State University, School of Earth and Space Exploration, Mars Space Flight Facility, PO BOX 876305, Tempe, AZ 85287-6305.

Introduction: Images of planetary bodies in our solar system are some of the most widely utilized data products available to the planetary science community. These data have been acquired from the beginning of NASA's exploration of the solar system to the present day. Imaging cameras and spectrometers such as the Viking Orbiter Visual Imaging Subsystems (VIS) [1], the Mars Orbiter Camera (MOC) [2] wide angle and narrow angle instruments, the Thermal Emission Imaging Systems (THEMIS) [3, 4] visual and infrared imagers, the High-Resolution Stereo Camera (HRSC) [5, 6] visible imager, and the Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE) [7], Context Imager (CTX) [8], and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [9] have all provided new and unique views of the planet that have revolutionized the manner and detail in which Mars is studied. Additionally, high-resolution spectral data from the Thermal Emission Spectrometer (TES) [10] and CRISM have provided a wealth of mineralogical data which are widely used by the community to characterize the geology and planetary history of Mars [11].

Data Processing Tools: In this abstract, we present an open source toolkit developed by the Mars Space Flight Facility at Arizona State University that is used to calibrate, analyze, and visualize THEMIS data. Recently this toolkit has been applied to additional datasets [e.g. 12].

DaVinci (http://davinci.asu.edu) is an interpreted language that looks and feels a lot like C, but has additional vector oriented features that make working with large (multiple gigabytes) blocks of data significantly easier. This makes DaVinci well suited for use as a data processing tool, allowing symbolic and mathematical manipulation of hyperspectral data for imaging spectroscopy applications. DaVinci provides support for importing and exporting current Integrated Software for Imagers and Spectrometers (ISIS, http://isis.astrogeology.usgs.gov) data formats, among a variety of other data formats including VICAR, multiband GeoTIFF, CSV/ASCII and other commonly supported image formats (e.g. PNG, JPEG, BMP). DaVinci allows the end user to develop image-processing algorithms, query databases, and directly download images and maps of Mars, the Moon, and numerous other bodies all with an interactive scripting interface. Its plotting and image display capabilities let the user visualize the effect of data processing in real-time. Processing algorithms developed in DaVinci can be easily integrated with ISIS to provide a flexible compliment to the established ISIS routines. Additionally, DaVinci provides additional tools but complementary tools to ISIS that allow users to mosaic hundreds to tens-of thousands of images together with various levels of normalization and processing [13].

Feature Highlights and New Developments:

Standalone ISIS3 Readers: A major development in the past year for DaVinci is a stand-alone ISIS3 file reader that does not depend on the ISIS3 API. In the past, a full installation of ISIS and a user-compiled version of DaVinci were required to enable the I/O of ISIS3 files, creating a large barrier to its use. Recently we have developed a stand-alone reader that will be available on all supported operating systems (OS X, Debian/Ubuntu, RedHat/CentOS, and Windows). The ISIS3 writer is currently under development and is expected to be complete within the year.

JMARS-DaVinci Link: The Java Mission-planning and Analysis of Remote Sensing (JMARS, http://jmars.asu.edu) tool provides easy identification and correlation of various datasets and derived products. It allows data from all the instruments listed in the introduction (and datasets from other planetary bodies) to be viewed in either a map-projected or 3D shape model view (see JMARS abstracts [e.g Dickensheid et al.; Hagee et al.] at this workshop for additional information).

DaVinci can read data directly from the back-end of JMARS, manipulate it, and display the result in context with other datasets in JMARS. The DaVinci-JMARS link is a straightforward way for end-users to directly and quickly ingest their data for a single JMARS session or to be stored on the JMARS servers for delivery to any JMARS instance. Users with access to Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data of the Earth can process, stretch, and perform spectral mixture analysis results that can be viewed in JMARS without outputting a geo-referenced file. The back-end link in JMARS is not specific to DaVinci, relying on a standard web-based protocols and can be readily modified for users of ENVI/IDL or other image processing toolkits such as those developed for Python.

Geospatial Data Using DaVinci and GDAL: DaVinci utilizes a script library that leverages on the

Geospatial Data Abstraction Library (GDAL). This suite of functions provides the ingestion of raster and shape (e.g. polygon, point, line etc.) files while preserving geospatial information. This suite of functions permits the projection of unprojected data from ground control points, the reprojection of data (raster and shape) from one projection to another (including projection matching), the rasterization of shapes, the reading of ~30 additional file types supported by GDAL and the writing of multi-band GeoTIFFs. All projection and file I/O is handled by GDAL so updates and improvements made by the highly active GDAL/PROJ open source community are directly available to DaVinci. This set of geospatial aware functions also integrates directly with the aforementioned JMARS-DaVinci link.

Stand Alone THEMIS Processing:

A large volume of literature has been published utilizing advanced image and data processing algorithms designed for the compositional analysis of THEMIS and TES data. Publications that utilize DaVinci explicitly include: 1) TES atmospheric correction [14], 2) THEMIS atmospheric correction and instrument calibration [15], 3) THEMIS calibration, line correlated, and uncorrelated noise removal algorithms [13], and 4) mineral abundance determinations [e.g. 16, 17-26]. The data processing steps to both mosaic and utilize well calibrated THEMIS data are presented by *Edwards et al.* [13].

However, these steps rely on a complicated sequence of commands that include reading and writing files, querying databases, use of ISIS commands, etc. We have developed a suite of stand-alone processing scripts that are now distributed with every version of DaVinci and significantly streamline the processing of THEMIS data. These commands are automatically updated when DaVinci's "script library" is updated and once the user includes the executable path in their standard path, are useable on the command line from any directory. These scripts include: 1) pre-projection processing, 2) post-projection processing, 3) visualization processing and GeoTIFF generation for easy importing into the user's tool of choice. These 3 steps (and ISIS projection steps) are wrapped in a processing script which executes a set of user-configurable defaults and will carry out the process defined in *Edwards et al.* [13] with no user input. While automatic atmospheric correction is under development [e.g. 27] and is not deployed yet, it will be incorporated in this pipeline as soon as it has completed validation.

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