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BIG LUNAR DATA VISUALIZATION AND ANALYSIS

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ABSTRACT

NASA's earth and planetary spacecraft return large amounts of remote sensing data, such as imagery and raw science measurements, in support of remarkable research. Not only does the data lead to new scientific discoveries about our planet and the solar system, it provides a wealth of information to educate, inspire, and engage the public at large. To leverage this rich data for mission planning, scientific research, public outreach and education, it is essential to make it accessible and understandable, analyzable, all while appealing to their interests. This presentation will highlight web-based capabilities that showcase NASA's large volume of lunar data collected from past and current Moon missions. It is particularly relevant as the new Administration has more plans for the Moon. We will illustrate big data visualization and analysis in easy-to-use and interactive mediums for diverse use.

1. INTRODUCTION

Meeting the challenges of space exploration has resulted in new knowledge that has kept NASA and JPL world leaders in big data science and technology. We, NASA's Solar System Treks project development team at JPL, under the management of Solar System Exploration Virtual Research Institute (SSERVI) [1], have developed a system that includes a set of web-based portals and a suite of interactive visualization and analysis tools to enable mission planners, scientists, and engineers to access a large volume of mapped data products and models from past and current missions. Currently, three web-based portals are publicly available for discovering the Moon, Mars and Vesta. This presentation will provide an overview of this system highlighting its lunar web portal, Moon Trek (https://moontrek.jpl.nasa.gov) that was designed and developed specifically for exploration of our Earth's Moon. We will also demonstrate its uses, features and capabilities, highlighting big lunar data visualization and analysis innovations.

2. MOON TREK

Moon Trek provides a suite of interactive tools that incorporate observations from past and current lunar missions, creating a comprehensive lunar research and educational web portal. The online web portal allows anyone with access to a computer to search through and view a vast number of lunar images and other digital products without having to download any application to the computer. The portal provides easy-to-use tools for browsing and searching, data layering and feature search, including detailed information on the source of each assembled data product from NASA's Planetary Data System (PDS) [2]. While mission planning was initially the primary emphasis when our work started in the NASA Constellation Program era, Moon Trek has evolved and expanded to address the lunar science community, the lunar commercial community, education and outreach, and anyone else interested in accessing or utilizing lunar data. Its visualization and analysis tools allow users to perform analysis of big volumes of lunar data such as lighting and local hazard assessments including slope, surface roughness and crater/boulder distribution. Moon Trek features a generalized suite of tools facilitating a wide range of activities including the planning, design, development, test and operations associated with lunar sortie missions. Sharing of multi-layered visualizations is made easy with the ability to create and send using URL-encoded links. Moon Trek is also a powerful tool for education and outreach, as is exemplified by being designated as a key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, as data service to NASA's Eyes on the Solar System, and as serving of data to a growing community of digital planetariums.

3. BIG DATA

Large amount of lunar data from the Apollo era to the latest instruments (such as the high definition camera) on board the Lunar Reconnaissance Orbiter (LRO) have been collected by NASA and other international space agencies. Although raw data/images and calibrated data sets are accessible via PDS, additional processing is required to transform these raw data and images to geo-referenced, aggregated and mosaicked images in order for Geographical Information System (GIS) like Moon Trek to display them as rich visualization layers that are highly valuable for future mission planning and development, scientific research as well as for general public. Thousands of such

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processed higher level visualization data products that are map projected, georeferenced, ortho-rectified and controlled under the same Lunar Orbiter Laser Altimeter (LOLA) network are made available through the Moon Trek. These large amounts of data Moon Trek manages ranges from a few gigabytes to hundreds of gigabytes in size with new data products adding to the system when they are available. One example of the data Moon Trek serves is shown in Figure 1. It is a close-up image taken by the narrow angle camera aboard the Lunar Reconnaissance Orbiter. The image is (only a sub-image is shown) has a resolution of 5064x52224 (264 megapixels) as a 264 megabytes TIFF image. The physical resolution of the image is approximately 1 meter/pixel. We currently have thousands of these images.

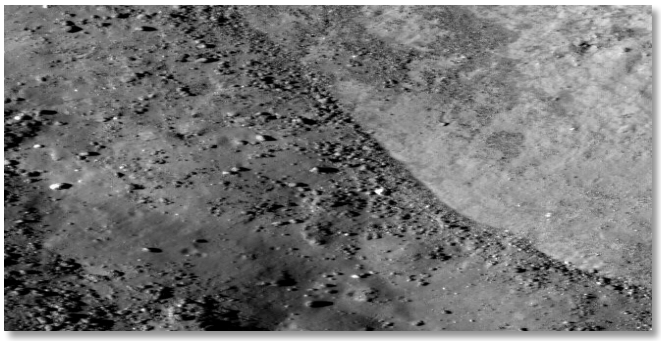

Figure 1. LRO Narrow Angle Camera Image

Another example shown in Figure 2 is a composite image consisting of multiple images taken by Apollo 15 Metric Camera imaging system as it orbited the Moon. The size of the image is 49152x33496 (1.6 gigapixels) as a 3.3 gigabyte TIFF image. The physical resolution of the image is approximately 10 meters/pixel.

Figure 2. Apollo 15 Orbit 33 Mosaic

Figure 3 shows a complete lunar map composed of many regional images collected by the Ultraviolet/Visible camera (UVVis) aboard the Clementine spacecraft. The image size is 92160x46080 (4 gigapixels) compressed with JPEG2000 to 200 megabytes with a physical resolution of approximately 100 meters/pixel.

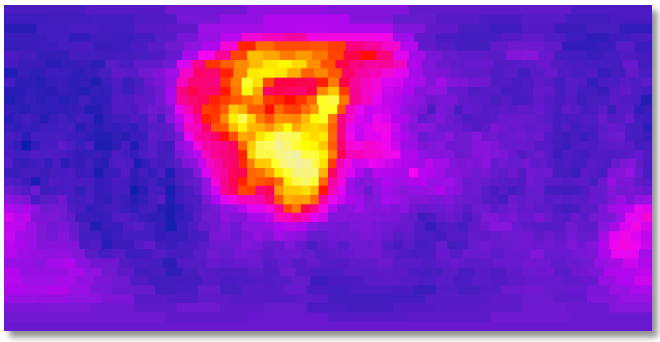

Figure 3. Potassium Concentration Map

Despite this ever-increasing amount of data, Moon Trek must provide users with the best performance for browsing, viewing and analyzing the vast amounts of data available in a timely manner.

4. SYSTEM TECHNOLOGIES

Moon Trek as well as other web portals provided by the Solar System Treks project (e.g., Mars Trek https://marstrek.jpl.nasa.gov) is built on a Service Oriented Architecture (SOA) [3] that is scalable and extensible for all planetary bodies. All Trek portals are supported by a common backend infrastructure and use a common frontend visualization framework. Figure 4 below depicts the high level architecture of the Solar System Treks system that serves as the foundation of the Moon Trek (as well as other Trek portals). The infrastructure provides core services for data ingestion, data management, image tiling using hadoop [4], arcGIS [5], and workflow using cloud computing for various computation and data analysis services, search via SOLR [6] and download. By taking advantage of Amazon Cloud Front [7], the system securely and effectively delivers Moon Trek data products to the front end. It provides OGC [8] compliant standard web services APIs for accessing all data products. The frontend framework takes advantage of HTML5 [9] frontend user interface. It employs a flat open space design and implementation that maximizes usability with modular tools and widgets. It includes in browser over sampling that stretches the image dynamically when zoom in past its resolution level. It is responsive to different sizes and form factors. It is embeddable into other browsers. It employs Cesium [10], a JavaScript library that supports 3D globe view for visualizing dynamic data with high rendering performance, precision, visual quality and ease of use. By using standard keyboard gaming controls, Moon Trek allows users to maneuver a first-person visualization of "flying" across the surface of the Moon. Users can also specify any area of interest to generate STL [11] or OBJ [12] files for creation of physical models of surface features with 3D printers.

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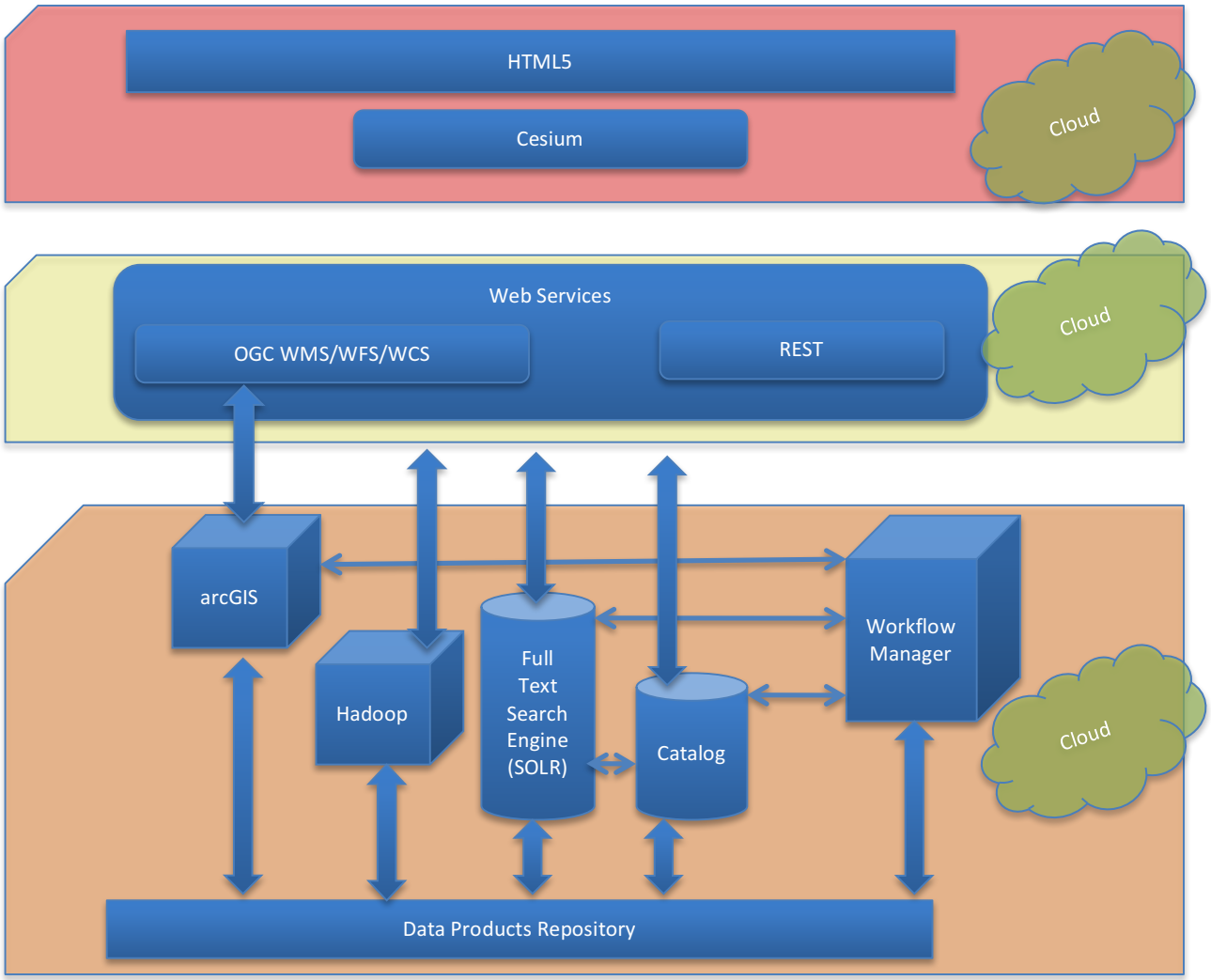

Figure 4. High Level Architecture

5. SUMMARY AND CONCLUSION

NASA's Solar System Treks project has grown considerably from its initial goal of providing a mission planning tool for Lunar exploration. Recognizing the big data trend and challenges, the team had the foresight to architect and design the system (including a combination of a backend infrastructure and a common user interface framework) to be scalable and extensible. The system is now successfully providing capabilities for multiple activities including mission planning, scientific research, decision making, as well as public outreach for other planetary bodies via its web portals. In addition to continual enhancements to the system, the team continues to expand its capabilities to new destinations and new research. We also encourage and invite

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the user community to provide suggestions and feedbacks as the development team continues to expand the capabilities of the system, its related products, and the range of data and tools that we have provided.

6. ACKNOWLEDGEMENT

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