CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: AirFlow Processing Pipeline	
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Project Overview:

U.S. and international spacecraft missions have acquired enormous numbers of images and data about the planets and their satellites. While these data sets support furthering our knowledge of the universe, they are also used for supporting planetary rover missions, helicopter missions and the planned human exploration back the Moon and Mars. The USGS Astrogeology Science Center (ASC) plays a critical role in providing these foundational data products for current and future missions. For example (Figure 1), a recent mosaic (called the orbital map in the figure) was created at ASC and will be used to safely land the Perseverance Rover onboard the Mars 2020 mission.

To help researchers and the public make similar mosaics, ASC already hosts an on demand image processing pipeline for planetary images which allows images to be spatially registered to the surface (map projected) and converted to the user's preferred file format (https://astrocloud.wr.usgs.gov). However, this pipeline is currently locked into one defined path. To enable a much more valuable tool, we would like to see this pipeline highly configurable and allow researchers and the public to optimize the processing steps available in our planetary software suite (ISIS3). There are no means for a research to change this current pipeline which out manually installing and creating and manually linking ISIS3 routines together. Learning ISIS3 is no small undertaking and this project will greatly increase the reach of our tools.

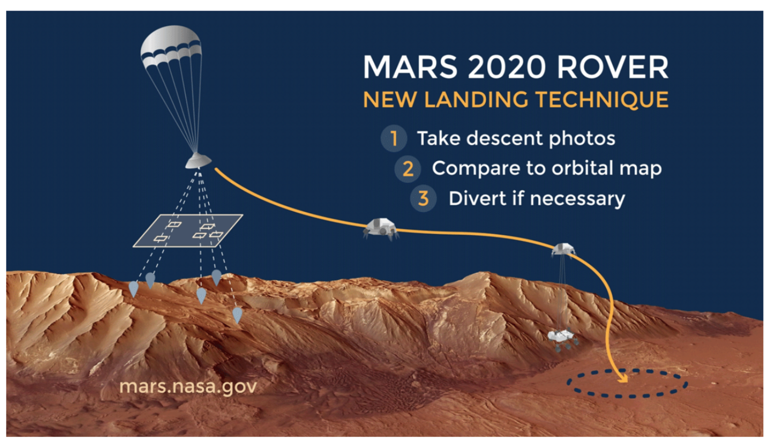
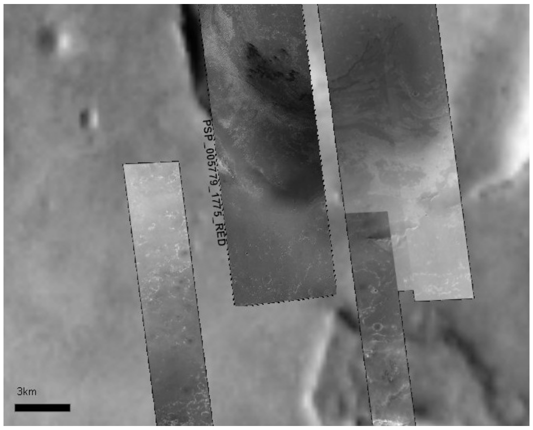


Figure 1. Showing the new Terrain-Relative Navigation to help land safely on Mars. For more see: https://www.usgs.gov/news/mars-2020-mission-be-guided-usgs-astrogeology-maps. Image: NASA

Thus the goal of this project is develop this graphical workflow specification and monitoring tool; specifically this tool will allow users to graphically specify a processing pipeline within the Apache AirFlow framework (https://airflow.apache.org) with a customizable directed acyclic graph (DAG) that allows users to select/specify all processing steps in a pipeline. The current processing pipeline provided by the Map Projection on the Web (POW) service has a fixed set of steps, this project would be to make the steps dynamic to complete processing up through any step as defined by the user. For example, people working with the images may only want the initial step of converting the files from the original mission format to the ISIS3 cube format or to have them converted and SPICE kernels applied (https://naif.jpl.nasa.gov/naif/spiceconcept.html), which defines the spacecraft location and pointing information. An option for output will also be to support Cloud-optimized GeoTIFF (COG) with a SpatioTemporal Asset Catalog (STAC) JSON record describing the output and a map viewer for viewing these records. Both writing COG and a preliminary STAC record is already supported. Connecting the existing web map interface, based on the existing Leaflet interface, will need a little support from this team.



Example of images processed from POW overlain on a global Mars base map. Image: USGS, ASC

Project Requirements

The goal of this project is to take the existing POW pipeline and break down the separate processing steps into separate AirFlow DAG processes to allow users full control over the steps that are run in their processing pipeline. The web application will provide a graphical drag-n-drop interface in which users can select desired processing steps, graphically arrange them into the desired processing workflow, then edit/configure each step with various parameters (if applicable). The capabilities this interface needs to support are:

- Specify the files to be processed either through a file path or from a CSV download from a Pilot search result (https://pilot.wr.usgs.gov)
- Select which of the processing steps in the POW pipeline to apply to the list of files
- Specify the processing options for each step such as what map projection to use and what file format to convert the finished products to
- Specify either an output directory (for USGS Astrogeology Science Center team members) or to have the finished files to be packaged for download using the standard POW distribution
- On form for output will be the Cloud-optimized GeoTIFF (COG) with a SpatioTemporal Asset Catalog (STAC) JSON record describing the files and connecting to the Leaflet map viewer for viewing these records

Our team here at USGS can provide the existing POW solution, the steps we have taken to implement AirFlow for the processing, and a development environment for running the pipelines.

We expect these overall specifications to become more precise as part of the early design and requirements process.

Knowledge, skills, and expertise required for this project

- Experience with Python will be essential as the POW pipeline and AirFlow are all written in Python.
- Some familiarity with the underlying architectures of distributed systems including processing clusters and using Kubernetes or Docker Container to deploy and manage environments.

Equipment Requirements:

- We will provide access to a development environment for running the pipelines via Anaconda or Miniconda.
- We can also work with the team to run this our processing cluster using SLURM (cluster workload manager).

Software and other Deliverables:

- AirFlow framework with an interface as described above. The interface can be an API, web tool, or other method the team comes up with.
- Design/Architecture documents demonstrating the system being run in as a single instance.
- Kubernetes or Docker container for deploying and easy setup.
- Write support for Cloud Optimized GeoTIFF (using the existing Geospatial Data Abstraction Library, GDAL) and existing Leaflet map-based interface.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub, BitBucket,or some other version control repository; and as a physical archive on a USB drive. We will provide a repository for the source he USGS Astrogeology's Github page.

References:

- Apache Airflow, https://airflow.apache.org/
- Hare, T.M., S.W. Akins, R.M. Sucharski, M.S. Bailen, and J.A. Anderson, 2013, Map Projection Web Service for PDS Images, LPSC XXXXIV. https://www.lpi.usra.edu/meetings/lpsc2013/pdf/2068.pdf
- STAC and Cloud Optimized TIFF:
- https://www.eclipse.org/community/eclipse_newsletter/2018/december/geotrellis.php
    - Github URL: https://github.com/USGS-Astrogeology/PDS-Pipelines