FEATURE DETECTION AND LINE OF SIGHT ANALYSIS ON THE MOON TREK PORTAL. N. Gallegos[1], S. Malhotra[2], C. Nainan[3], Solar System Treks Team[4] , and B.H. Day[5], [1]Jet Propulsion Laboratory, California Institute of Technology (natalie.gallegos@jpl.nasa.gov), [2]Jet Propulsion Laboratory, California Institute of Technology, [3]Jet Propulsion Laboratory, California Institute of Technology, [4]Jet Propulsion Laboratory, California Institute of Technology, [5]NASA Ames Research Center.

Introduction: The Moon Trek portal found at https://trek.nasa.gov/moon aims to provide the scientific community as well as the general public access to lunar data collected from various missions. The portal also offers a suite of tools with the goal of allowing users of the portal to analyze the data for the purposes of education, mission planning, and research. Such tools include elevation profilers, crater and rock detection, lighting analysis, and slope analysis to name a few. Moon Trek is further expanding its analytic capabilities by adding feature detection and line of sight analysis to its toolset.

Feature Detection: The feature detector, similar to the rock and crater detection tools, seeks to detect features on the lunar surface using orbital imagery. Unlike the detection tools currently on Trek, the feature detector is built to be generic, trainable to seek out any feature when provided a training set for the feature in question. The tool currently supports detection of craters, rocks, and lunar pits.

Adding a generic feature detector to the platform further aligns Moon Trek with its goal of offering mission planning utilities to the scientific community. The detection of various lunar features can be used for chronological aging of lunar surfaces and hazard detection and avoidance during a mission planning phase.

Feature Detection Methodology. The feature detector takes a deep learning approach in finding features from orbital imagery. This is in contrast to the rock detector that uses classical image processing techniques, and the crater detector that uses both image processing and a convolutional neural network. The model used in the latest detection tool is a Faster Region Based Convolutional Neural Network (Faster-RCNN) [1] with a finetuning approach. More succinctly, the finetuning approach uses a model which has been developed and trained on a different and larger training set. The classification layer is replaced to detect features of the chosen domain (rocks, pits, craters, etc.) The model is then trained with smaller training sets.

Currently we use Narrow Angle Camera (NAC) images from the Lunar Reconnaissance Orbiter Camera (LROC) as input. However, the model can be trained on orbital imagery from any mission. The tool's output includes the NAC image with bounding boxes over detected features as shown in Figure 1, and an ascii file showing pixel coordinates of each detected feature.

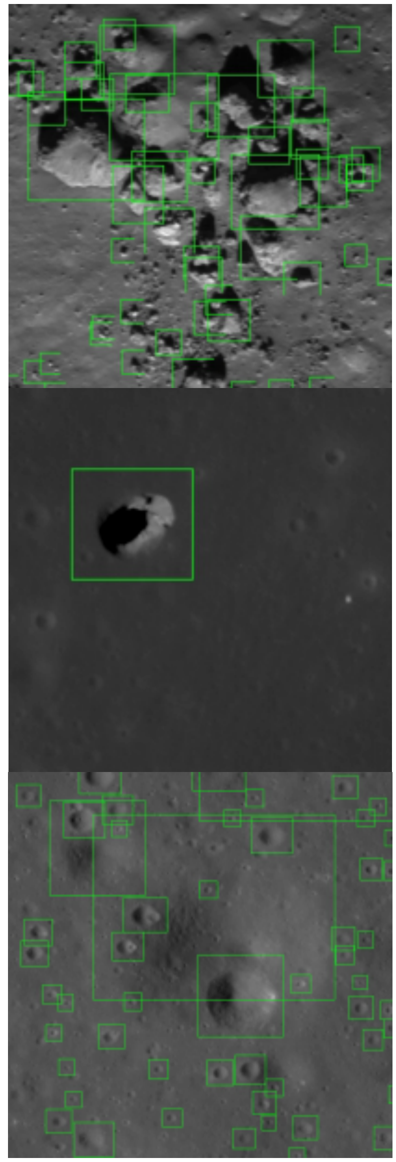

Figure 1: Sampled feature detection outputs from top to bottom, rocks, lunar pits, and craters.

Feature Detection Future Work. Pending work for the detector includes training the model to detect features on varying lighting conditions, for example detecting craters on polar regions of the moon. Additional work includes adding an interface where users can upload their own training sets and train our model with labels provided by users.

Line of Sight Analysis: The second tool to be added to the Treks is the Line of Sight (LoS) tool. This utility searches for windows of communication or a "line of sight" between any two entities. Entities include orbiters, rovers, planetary bodies, topographical locations on planetary bodies such as DSN ground stations, and asteroids to name a few. In addition to establishing communications between two entities, the tool also takes into account local terrains of the entities in question.

The LoS tool attempts to answer questions about establishing communications between a rover and an orbiter, or an orbiter and a ground station. In mission planning, this tool can be used to determine possible traverses for a rover that must maintain communications with a lander, or find intervals of communication to an orbiter when a rover or lander are near an obstructing surface feature such as a crater rim or mound. The tool is capable of more detailed computations, such as searching for lines of sight between an instrument on an orbiter/rover to another entity. A RESTful implementation is integrated into the tool to allow for easy access to users from their browsers.

Line of Sight Methodology. LoS uses NAIF SPICE System software for computations of planetary geometries [2]. In addition to this powerful software, LoS also employs in-house software for converting Digital Elevation Models (DEMs) into SPICE compatible plates for use in our computations. As input, the tool accepts a DEM, start and end UTC dates and times for searches, and topographical coordinates on planetary bodies or mission IDs. Given that some computations can be quite complex depending on use case, users can use the UI imaged in Figure 2 for simple use cases. Additionally, users can potentially provide their own SPICE kernels and DEMs for computations on missions of their choosing.

Currently the tool has built in terrains for the Lunar Surface, Martian surface, and DSN ground station locations. SPICE Kernels for Mars Science Laboratory Rover, Mars Reconnaissance Orbiter, Lunar Reconnaissance Orbiter, and all DSN ground stations are included in the tool for users who want to peruse the tool's capabilities without needing a complete knowledge of underlying SPICE workings.

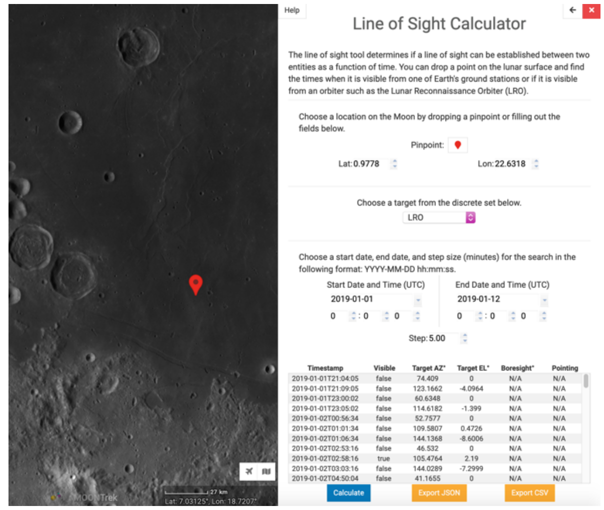

Figure 2: Line of Sight UI from Moon Trek showing visibility results from LRO to a surface point on the moon for interval 2019-01-01 to 2019-01-12

Line of Sight Future Work. Potential work for the Line of Sight tool includes adding an interface to allow users to upload input files for their own computations (SPICE Kernels and DEMs). Returning results in higher resolution when an obstruction is detected. i.e. find the nearest time for start of obstruction.

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References: [1] Shaoqing R. et al. (2016) *Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks.* [2] Charles A. et al. (2017) *A look toward the future in the handling of space science mission geometry*, Planetary and Space Science, 9-12.