Feature Detection and Line of Sight Analysis on the Moon Trek Portal

Abstract #7063

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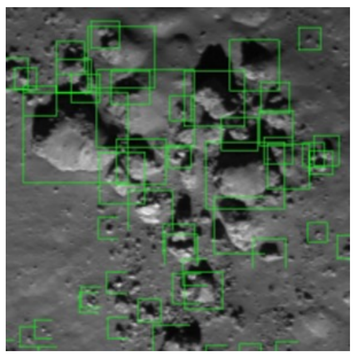
The Moon Trek portal found at https://trek.nasa.gov/moon aims to provide the scientific community as well as the general public access to lunar data collected from various missions. The portal also offers a suite of tools with the goal of allowing users of the portal to analyze the data for the purposes 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. Below we show outputs from the two tools respectively, and provide minor details for the methodology behind each tool.

Feature Detection

The feature detector is implemented using the latest state of the art deep learning techniques. The feature detector uses the Faster Region Based Convolutional Neural Network (Faster-RCNN) model for the detection and recognition of features. Such models are meant to be trainable on various features, and thus can be trained to detect distinct geographical features on the lunar surface by providing the appropriate training sets.

The feature detector has been trained with panchromatic images captured from the Lunar Reconnaissance Orbiter for three lunar features: craters, rocks, and lunar pits.

Feature Detector Outputs: Rocks

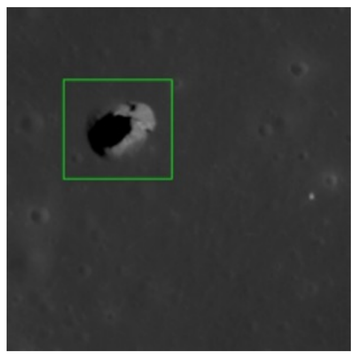


One of the outputs of the feature detector is an image with detections labeled with bounding boxes. The image to the right shows a closeup of result image M109309907LC, where detected rocks are labeled with green bounding boxes.

```
[ 1147.3865 11651.018 1332.8679 11843.103 ]
[ 4587.0366 16191.522 4636.715  16247.898 ]
[ 3677.5305 3003.9065 3741.9553 3047.919  ]
[ 57.609524 40597.35  112.09732 40656.01  ]
[ 2060.2112 32539.205 2179.0623 32642.693 ]
[ 4618.8335 16204.285 4671.4624 16259.953 ]
[ 4422.415  3473.05   4510.932  3533.128  ]
[ 4015.3015 15152.886 4075.1594 15201.005 ]
[ 4194.9316 6249.664  4282.963  6328.369  ]
[ 498.0579 49317.99   559.8377  49368.68  ]
[ 275.1162 5057.9287  312.54483 5096.6724 ]
[ 4112.536  5807.873  4168.7095 5853.244  ]
[ 2770.5771 32142.68  2853.357  32213.623 ]
[ 3799.1287 46748.39  3851.1904 46790.215 ]
[ 2875.8555 32120.87  2939.9946 32175.19  ]
```

Second output from feature detector, a text file with the bounding coordinates of each detected feature in pixel space.

Feature Detector Outputs: Pits

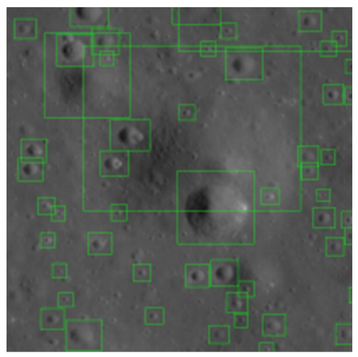


Feature detection of a single lunar pit on image M184068107LC, labeled by a green bounding box. There are few known lunar pits, and many craters. The feature detector successfully distinguished between the two.

```
[  710.758  28522.648  797.24176 28601.328  ]
```

A single line written to the ascii output for the detection of a lunar pit in the LROC image.

Feature Detector Outputs: Craters



Result close-up of crater detection using the feature detector on image M114131846RC. Craters are labeled with green bounding boxes.

```
[ 3302.6882 47903.156   3345.601  47945.855 ]
[ 420.0038  12623.822  461.09503 12662.053  ]
[ 207.6892  28316.29   228.05612 28336.941  ]
[ 1239.7855 10818.65    1438.2183 10974.102 ]
[ 3924.1064 51584.758   3967.692  51625.766 ]
[ 4799.2085 38799.82    4845.8267 38841.816 ]
[ 192.5841 1508.2661  366.029  1649.1764 ]
[ 3433.2737 13815.854   3454.0952 13837.092 ]
[ 2247.7766 27388.768   2289.3193 27428.314 ]
[ 4412.1675 12555.898   4548.1367 12682.835 ]
[1396.1282 7269.012  1421.4612 7292.3926]
[ 3594.2578 28660.44    3752.5564 28803.5   ]
[  635.5344 13798.497    670.3428 13831.518 ]
[ 287.52646 5075.271    306.49866 5094.051  ]
[ 4204.3203 12827.955   4370.0483 12961.421 ]
[ 2107.8154 46571.34    2143.7427 46605.695 ]
[ 3083.8816 49414.41    3132.9143 49459.88  ]
[ 3208.0981 33459.76    3416.1118 33648.98  ]
```

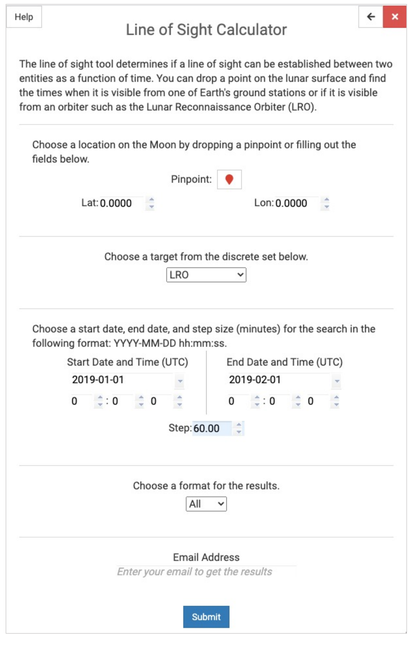
Secondary output of the feature detector. Crater detections are recorded in an ascii file. Coordinates are in image space, and are given the lower left, and upper right corner of the bounding box.

Line of Sight Analysis

The Line of Sight tool searches for ”lines of communication” between two entities (planets, spacecrafts, topographical locations). It uses SPICE software for computing planetary geometries, and uses high resolution Digital Elevation Models to model the terrain for each computation.

As a result, the tool can find obstructions in communications or visibility due to planetary geometries, and/or local terrain obstructions.

Line of Sight Inputs



The Line of Sight tool is accessible through the trek portal. As input, users can select from a set of discrete entities to target from a location on the moon. These include ground stations on earth, and the LRO spacecraft. The coordinates of the lunar location must also be provided. Finally, the search interval in UTC time must be provided. The tool will automatically select the highest resolution DEM available for computation.

Line of Sight Outputs

	A	B	C	D	E
1	timestamp	visible	illuminated	orbiter_az	orbiter_el
2	2019-01-03T21:48:41.641	FALSE	FALSE	60.3694	0
3	2019-01-03T21:49:41.64100	FALSE	FALSE	70.5605	0.668
4	2019-01-03T21:50:41.64100	FALSE	FALSE	81.5701	0.7883
5	2019-01-03T21:51:41.64100	FALSE	FALSE	92.7121	0.3079
6	2019-01-03T21:52:41.64100	FALSE	FALSE	103.2505	-0.7078
7	2019-01-03T23:45:04.801	FALSE	FALSE	51.5327	0
8	2019-01-03T23:46:04.80100	TRUE	FALSE	61.1057	1.1504
9	2019-01-03T23:47:04.80100	TRUE	FALSE	72.0704	1.8241
10	2019-01-03T23:48:04.80100	TRUE	FALSE	83.8913	1.8588
11	2019-01-03T23:49:04.80100	TRUE	FALSE	95.6996	1.2086
12	2019-01-03T23:50:04.80100	FALSE	FALSE	106.6321	-0.016
13	2019-01-04T01:41:42.754	FALSE	FALSE	45.0516	0
14	2019-01-04T01:42:42.75400	TRUE	FALSE	53.9975	1.4992
15	2019-01-04T01:43:42.75400	TRUE	FALSE	64.7036	2.6183
16	2019-01-04T01:44:42.75400	TRUE	FALSE	76.8728	3.1226

Example output of Line of Sight. A single CSV file (or JSON file optionally) detailing the visibility of an entity at each timestamp. Additionally, metadata such as the entities elevation and azimuth angle with respect to the lunar surface point during the given timestamp.