IMAGE AND LIDAR DATASET OF THE WEST DESERT SINKHOLE: AN ANALOG FOR STEEP-WALLED PLANETARY PITS. J. S. Ford[1], P. J. Callaghan[1], U. Y. Wong[2], H. L. Jones[1], W. C. Whittaker[1], W. L. Whittaker[1],[1]Carnegie Mellon University, [2]NASA Ames Research Center

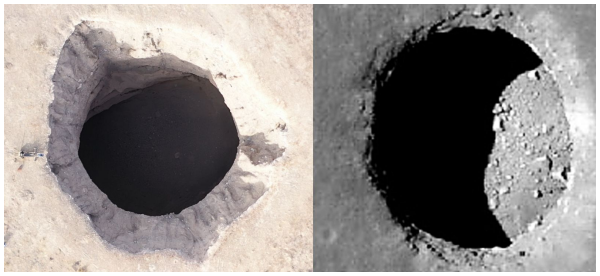

Figure 1. The West Desert Sinkhole is a close terrestrial analog to a steep-walled lunar pit.

Introduction

This work presents a LIDAR and image dataset for studying steep-walled planetary pits. A custom camera gantry captured sets of 1500 images from 27 locations encircling the West Desert Sinkhole at heights and angles relevant for small rover exploration, mapping, and modeling. The combined laser scans provide a dense, precise, textured model of the pit that is useful as ground truth for benchmarking image-derived models and algorithms, for developing and evaluating robot planning, and as a standalone data source for studying planetary pits. All images and laser scans are localized within a single coordinate frame using a survey instrument and are publicly available online. This paper describes the collection apparatus and procedures used to create the dataset, the organization of the dataset, and anticipated applications for the dataset.

Background

Lunar pits are primary scientific destinations with potential to reveal the formation history of the moon or to shelter human settlements from harmful radiation and micrometeorite impacts. While many proposed missions target lunar pits, existing lunar pit data derives from orbital imagery taken at oblique angles and resolutions too low for mission development. Wong et. al. identify King's Bowl Crater and the Indian Tunnel site as terrestrial analogs to lunar caves and lava tubes, and they provide detailed datasets for their study. However, these sites differ significantly in morphology from the lunar pits identified by the Lunar Reconnaissance Orbiter. Utah's West Desert Sinkhole is a more appropriate terrestrial equivalent due to its similar geological layering, dimensions, and appearance, as well as its accessibility to many sensing modalities.

Sensor Setup

PitCam — PitCam (Fig. 2) is a custom camera gantry designed to capture high-resolution images at prescribed poses around the edge of the West Desert Sinkhole. It features an x-y gantry capable of positioning a camera at three heights above the ground and three ranges from the edge of the pit. It carries a Prosilica GE4900-C color camera mounted on a FLIR PTU-D48E pan-tilt unit programmed to cycle through pan and tilt angles from -90° to 90° and -90° to 0°, respectively. At each camera pose, three to five images are captured at exposures bracketing the autoexposure value, enabling the creation of high dynamic range imagery (Fig. 3).

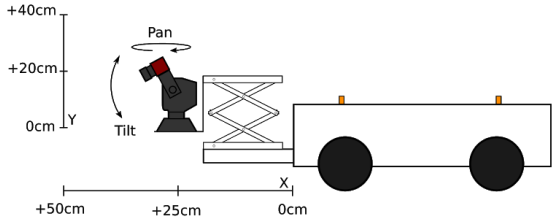

Figure 2. PitCam is a custom wheeled camera gantry which captures images at three ranges, three heights, seven pan angles, and six tilt angles.

Laser Scans — The dataset includes 44 laser scans captured using a FARO Focus 120 and a Focus[s] 350. Scans are registered against each other using fiducial spheres placed at the corners of a fence surrounding the pit. Each laser scan provides a dense, colored point cloud, and the combined scans form a comprehensive 3D model of the pit and its immediate surroundings.

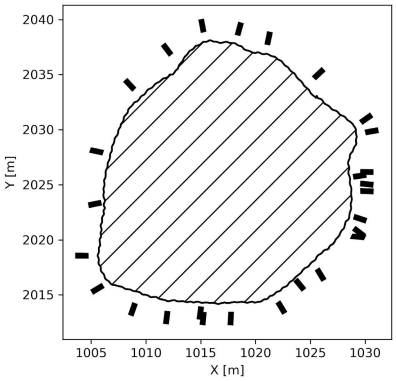

Figure 3. The dataset contains imagery from the 27 locations depicted above.

Total Station — PitCam and the two laser scanners carry target prisms used by a Leica TS15A 003" to accurately measure their pose. The dataset includes coordinates for every PitCam capture location and every laser scan. The expected accuracy of surveyed coordinates is +/- 2mm in the global frame.

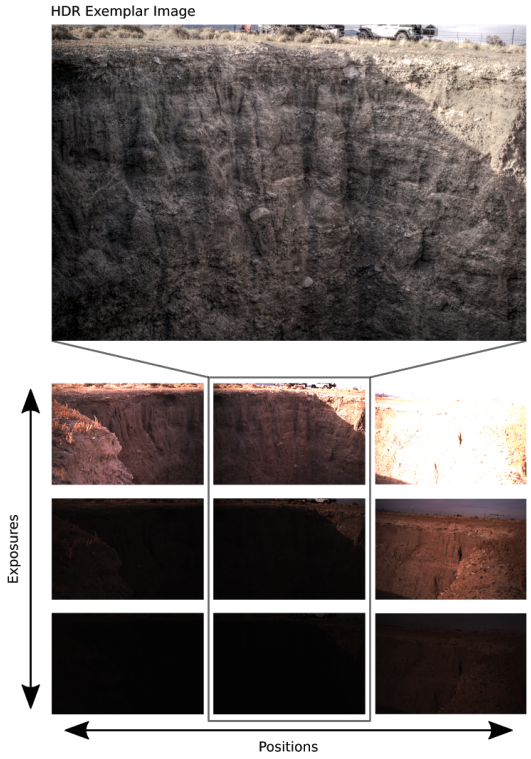

Figure 4. For each camera pose, multiple images with differing exposures are combined to create a single high dynamic range image.

Dataset

Statistics — The dataset contains 42,297 16-megapixel images and 44 high density laser scans. In total, it contains 585GB of imagery and 14.8GB of laser scans. Images were captured from 27 distinct locations surrounding the pit (Fig. 4). Sun elevations corresponded to 4x northern latitude at times from 7:40 AM to 4:53 PM MST over a period of five days from Nov. 12 to Nov. 16. 2019.

Organization — The dataset root directory contains one directory of images, one directory of laser scans, and two .csv files containing metadata. For each image, the metadata contains a timestamp, the 6-DoF pose of the camera in the global coordinate frame, the exposure used to capture the image, and the relative path to the image file within the dataset. For each laser scan, the metadata contains a timestamp, a pose, and a relative file path. Raw images are saved as 16-bit TIFF files in BayerGRGB format compressed via zlib.

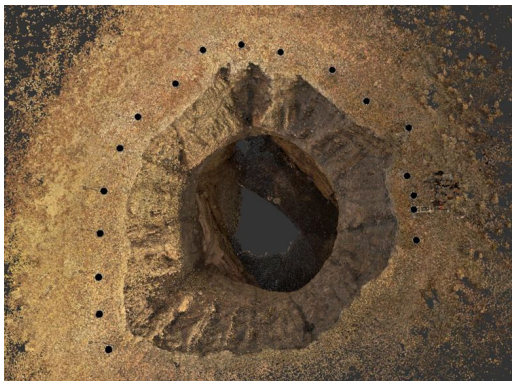

Figure 5. A three dimensional, top-down view generated by stitching eighteen LIDAR point clouds captured from the perimeter of the pit.

Applications

This dataset provides registered RGB-D point clouds and high-resolution imagery captured using various exposures under a range of lighting conditions. Applications for this dataset and derivative data products will include:

- Creation of DEMs for mission operations and traverse planning.
- Generation of terrain models for rover safeguarding, navigation, and autonomy development.
- Use as ground truth for science mapping development, including sensor placement, resolution trades, and algorithmic reconstruction evaluation.

Future Work

This dataset will inform the development of the first mission to explore and model a planetary pit using an autonomous micro-rover.

Dissemination

The dataset and associated code is available at www.westdesertsinkhole.com/data

Acknowledgements

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References

[1] Uland Wong, Warren Whittaker, Heather Jones, Red Whittaker. *NASA Planetary Pits and Caves Analog Dataset*. December, 2014.