PRELIMINARY RESULTS ON AUTOMATED CHANGE DETECTION IN THE AUTOCNET ENVIRONMENT.
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Introduction: Detecting changes as a means to quantifying temporal changes in multi-temporal, spatially enabled imagery is an important approach in planetary geology. Observing multi-temporal changes helps us to understand the processes that are shaping surfaces much more easily than simply studying the final landforms. Numerous studies have observed surface change on many worlds, including Mars, the Moon, Titan, and Io [e.g. 1-4]. We are developing tools for automated detection of changes, focused on Martian gullies where previous studies have used manual methods [e.g. 5].

As part of this work, we explored 4 different, currently unnamed, methods for studying particular changes: an image difference approach for detecting high level change on the surface; OPTICS clustering of ORB features approach for detecting large contiguous changes; A blob detector for bolder shift detection; feature based approach using RV coefficient for detection points of significant change.

Approach: Two important aspects of our approach: it does not require a high-resolution Digital Terrain Model (DTM) for the orthorectification of images; it does not use machine learning based approaches which depend on large sample sizes. This allows its use with a wider range of data. Change detection occurs between images pairs with significant temporal changes over some region of interest (ROI). Change detection proceeds with a few steps: (1) images are ingested into the USGS's Integrated Software for Imagers and Spectrometer (ISIS) cube format to leverage USGS camera models and bundle adjustment procedures; (2) cubes are inputted into spiceinit, an ISIS program that gives us a spatially enabled level 0 image; (3) for HiRISE, cubes are run through hical to produce a radiometrically calibrated level 2 image; (4) using Autocnet [6], a Python library developed originally for registration and bundle adjustment of large data sets, we run a pair-wise feature extraction and registration pipeline to programmatically produce a pair-wise control network; (5) jigsaw, ISIS's bundle adjustment software, is then used with the image pair and output control network to perform relative geodetic control of the image pair and updating camera parameters; (6) using the new camera pointing, the image pairs a projected onto each other creating a registered product and supporting data indicating the quality of the control; (7) at least one of the four change detection algorithms are ran with final results written out to in-memory tabular data structures.

At this time, we have implemented four different algorithms for detecting changes.

The first applies the ORB blob detector to a difference image created from the registered images. A heatmap is then generated from the points, giving a density map of expected change. This has shown to be most useful for getting high level knowledge of change within a pair of large images but does not lend itself to full programmatic change detection.

The second works similarly but searches for clusters of strong differences. We observed method 1 was effective at visually isolating large contiguous changes such as erosion along gullies through the heatmap but did not have a method to tag these large concentrations of features. So, we slightly modified it with the OPTICS clustering algorithm for detecting concentrations as a single feature and flag as detected change if it meets point density thresholds.

The third approach is a blob detector that searches for patterns consistent with changes in surface boulders, similar to [7]. This method detects boulders by using a blob detector to isolate pairs of bright and dark areas, presumably the lit and shadowed portion of a bolder, refined by using expected sun directions from the image's metadata.

The fourth algorithm compares subsections of the registered images via a pattern chip/search chip method using a RV correlation coefficient to find locations where the correlation are low. This functions by assuming chip pairs with low correlations represent locations that have changed. Each algorithm has some tunable parameters that influence the type of changes detected as well as the accuracy.

Status: We are in the process of testing these algorithms against both real and synthetic image data. Synthetic data was created by generating fractal topography and creating hillshade images with added noise. Changes were applied to the underlying topography, along with differences in illumination, and then the various algorithms simulate common surface topology changes. Preliminary results show good effectiveness detecting changes in these synthetic data.

Comparisons with real data are ongoing. Initial results have been promising in some examples but have failed to detect other types of real change. The effectiveness also depends on the quality of image registration, which is variable.

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