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PyNAPLE: Automated Lunar Impact Flash Crater Detection

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Abstract

When a Lunar impact flash is caught on camera an approximate location for this event can be obtained, and the resultant crater found. This approximate location, however, can span a large area; for a crater only a couple meters in size manually searching this area for the new crater proves problematic. We have developed a software pipeline which accounts for this approximation of area, and using Lunar Reconnaissance Orbiter Narrow Angle Camera (LRO NAC) images, we automatically form all valid temporal pairs which can be analyzed to locate the newly formed crater.

1. Introduction

Both the Moon and Earth are being constantly bombarded by a high quantity of small impactors. On Earth these small impactors vaporize while traveling through the atmosphere, however on the Moon the absence of a substantial atmosphere allows these impactors to reach the surface, resulting in the formation of a fresh crater. By deriving the average mass of the impactor, an estimate for the size of the formed crater can be made; finding the formed crater then allows for the estimates to be better constrained [1].

On the already crater covered surface of the Moon, manually searching for a specific crater is a near impossible task; computational methods are instead used to drastically cut down on the time needed to locate the newly formed crater [2]. Temporal imaging can be used, whereby two images, one taken before the impact and one after, are aligned with sub-pixel accuracy, and each pixel then divided by its corresponding pixel, creating a third image with the resultant values. Sections in which the two pixel values varied greatly appear highlighted, which trivializes the locating of any craters formed between the two images being taken, as demonstrated in figure 1.

While finding the new crater in the temporal pairs resultant image may be trivial, the difficulty comes from the fact that the number of possible temporal pairs in a given region grows exponentially as the area of said region increases. This leads to the need for automation, in order to efficiently iterate through potential temporal pairs in order to find a pair which contains the fresh crater.

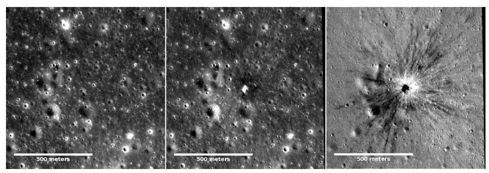

Figure 1: The result (right) from the division of the left and middle images shows how areas of change are highlighted. [3]

2. Method

PyNAPLE (**P**ython **N**AC **A**utomated Temporal **P**air **L**unar **E**valuator) operates in three distinct stages: Collation, Processing, and Evaluation.

During the Collation stage, the software connects to the Lunar Orbital Data Explorer (https://ode.rsl.wustl.edu/moon/) and retrieves a list of images which overlap with the approximate coordinates of the impact flash. This list of images is then split into two lists; images taken before the event, and images taken afterwards. These two lists can then be checked against one another for image pairs which have overlapping area and similar illumination conditions. Once these image pairs have been gathered they can be passed to the processing stage.

In the processing stage each image pair gets calibrated using the appropriate SPICE kernels, and then map projected into matching projections. From there the projected images are registered to one another using a maximum correlation pattern matching algorithm [4]. Using the control network of registered points generated by this algorithm, the before image is subsequently warped onto the after image, aligning all the unchanged geometry within the image, thereby allowing the division of pixel values into the resultant image.

Using the resultant image from each temporal pair, blob detection can be implemented to detect and crop out any areas of interest, generally denoted by a region of high contrast which likely contains the newly formed crater, into image thumbnails. In order to increase the likelihood of finding the formed crater the software iterates through image pairs until it reaches a predefined distance from the original approximate location.

3. Further Work

While the software has been extensively tested using locations and times where a crater is known to have formed, the next step is to run PyNAPLE on a list of 58 lunar impact flashes collected from the NELIOTA camera.

References

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