EPSC Abstracts
Vol. 13, EPSC-DPS2019-2075, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

# Real-time detection of impact flashes on the lunar surface

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## Abstract

Lunar impact flashes, which are lights generated when near-Earth objects (NEOs) impact onto the surface of the Moon, have been observed and monitored for the past two decades. That helped to study the population of objects, with relatively small to moderate size, while the Moon provides a large atmosphere-less surface. In this work, we propose two methods to detect such impact flashes in real time, which will allow a relatively quick follow-up to study and analyse the fresh craters of the impact on the surface of the Moon.

## 1. Introduction

The importance of detecting objects impacts on the surface of body without atmosphere comes from the fact that with such detection we obtain information related to the impactor, such as some physical properties (e.g. mass and size) [1, 2]. The Moon presents an ideal detector for such impacts due to the absence of the atmosphere, the large detecting area and the fact that these impacts generate flash which is observable from the Earth using small-aperture telescopes [3].

## 2. Detection methods

We developed two approaches that can be used to carry out real time detection of impact flashes on the surface of the Moon. Both approaches are based on the creation of a master reference frame which we called the Lunar background that is subtracted from images of the night side of the Moon, obtained using a high speed camera, in order to remove the inhomogeneous surface of the Moon and earthshine. The generation of such background is done by taking a median-combine of the frames prior to the frame under study up to around one second. After the subtraction, the resulting image should be essentially noise except for the bright pixels where an impact occurred.

The first detecting approach is based on subjecting the background-subtracted images to a threshold that the impact pixels must be above. Then to ensure that all the pixels detected to be above the threshold are not due to any artefacts, multiple filters were developed and implemented to eliminate such artefacts and confirm that the impact pixels form a Gaussian-like shape with a specified size in pixel as impact flash should usually resemble to some extent a Gaussian shape. As this method is based on the specification of a threshold, a good selection of the values of those criteria is required, as larger values can result on missing fainter impact and lower values can increase the number of artefacts, which leads us to the second approach.

The second method we developed, is to apply a Gaussian filter to the background-subtracted images, which will give two results. The first one is that it will smooth most of the artefacts which leads to their elimination and the omission of the cleaning filters in the first approach saving computational time. The second result is that it will enhance the impact pixels which leads to easy detection even for faint impact flashes overcoming the issue of incorrect selection the the threshold in the first method as low value of the threshold can be chosen without increasing the artefacts presence.

The most significant consideration when developing these real time detection methods was the fast execution and the short computational time in order to keep up with the running observations. Both methods were tested with data containing artificial impact flashes that we generated using a code that we developed and real data obtained from the NELIOTA project. The results of our examination show that both approaches can keep up with real time observations with the first approaches being faster than the second but less sensitive to fainter impact flashes.

## 3. Implications

This work is a part of a larger program that aims to detect impacts in real time during the observations, identify the lunar coordinates and attempt the discovery of the fresh craters using LRO data. This is explained in the poster presentation of this session by Raven Larson.

## References

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