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MoonZoo: a Citizen Science Project

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Abstract

Moon Zoo is a citizen science project that utilises internet crowd-sourcing techniques. Moon Zoo users are asked to review images from NASA's Lunar Reconnaissance Orbiter (LRO) [1] spacecraft and perform tasks such as measuring impact crater sizes and identifying morphologically interesting features. The tasks are designed to address issues in lunar science and to aid future exploration of the Moon. In addition to its potential in delivering high quality science outputs, Moon Zoo is also an important educator resource, providing information about the geology of the Moon and geophysical processes in the inner solar system.

1. Introduction to the Citizen Science Zooniverse

Moon Zoo is an online lunar citizen science project (http://moon.zooniverse.org) designed to address key questions in lunar science. It is one of several initiatives developed by the 'Citizen Science Alliance' (http://citizensciencealliance.org) in a collection of online citizen science projects known as the 'Zooniverse' (http://zooniverse.org). These projects are inspired by the highly successful Galaxy Zoo project (http://galaxyzoo.org), which harnesses the power of the Internet (i.e. 'crowdsourcing') to classify galaxies in support of astrophysics research. Using data provided by Galaxy Zoo users, the science team was able to demonstrate that the classifications carried out by members of the public were as good as those accomplished by professional astronomers [2].

2. Science Objectives

One of the main advantages of Moon Zoo [3], [4] and other citizen science projects, is the ability to analyse and classify huge amounts of data with multiple independent observations. Statistical analysis of the Moon Zoo output data offers a new perspective on outstanding lunar science topics. Furthermore, it may also aid the planning of future lunar exploration by robotic and eventual human missions. Additionally, educational research is being done to identify trends in the classification habits and site usage of Moon Zoo users over time, to measure understanding of lunar concepts, and to determine what motivates users to be part of this project.

2.1 Main Science Goals

Project 1 – Statistical population survey of small-to-intermediate craters (<3-4 km), with the aim to improve the understanding of small impact cratering in a diverse range of target rock materials. The resultant database of crater size, shape, and distribution can be employed to address key geological aspects: a) constraining cumulative crater frequencies as a function of crater diameter; b) producing a crater degradation-state index, an indicator of relative age, starting from the statistical analysis of ellipse/circle locations and variability among notations; c) identifying variations of local regolith thickness using the 'equilibrium diameter' method of determining regolith depth, thus helping to constrain regolith the regolith formation rate; d) surveying of small, elongated impact craters, which could represent low angle (<10 deg.) primary impacts or secondary craters; e) comparison of citizen science crater dimension studies with automatic computer algorithm methods, as a validation tool for each approach; f) noting craters that have boulders located outside their rims and assigning qualitative 'blockiness scale': since craters with blocky rims mostly represent impact events that have excavated below the local regolith depth into a more coherent stratum, then an estimate of a maximum depth of excavation can be derived, thus allowing the maximum regolith depth to be computed.

Project 2 – 'Boulder Wars!'. Users assess the degree of potential hazards across the lunar surface by

comparing two images and identifying the one with the higher boulder density. The goal is to build relative boulder-density hazard maps for the identification of suitable locations for sending future robotic and human missions to the Moon.

3. Public Reach Objectives

Given the size of the Moon and the high resolution of the LROC images (down to 0.5 m), Moon Zoo allows users to become real pioneers: there is a strong possibility for one to become the first human to observe and describe new lunar features at a sub-meter scale. Before starting the discovery journey, each citizen scientist (CS) undergoes training through interactive online tutorials introducing key aspect of lunar geology. The website also features a glossary rich in visual content and links to extra resources. The users also become part of a community that can interact through a forum moderated by experts and a blog featuring the latest 'hot news' from the lunar field.

4. Preliminary results

Following years where users have produced over eight millions crater annotations alone, spread across a wide range of lunar geologies and locations, we have now opened a new phase of targeted scientific objectives. Apollo landing sites represent the ideal setting for most Moon Zoo scientific objectives relating to crater statistical data, since we have direct age estimates from returned samples. The first of such exercises has seen the Apollo 17 region as the target of all users' efforts. To date, 20,627 CS have contributed in noting around 670,000 craters, with ~3% of these been classified as 'bouldery' and ~7% as being 'not-circular' [Figure 1]. We have also carried out an 'expert' crater survey of the same area and comparative analyses have been employed to evaluate eventual correlations and spotting trends. The results will form the basis of an interpretative procedure applicable to other Moon Zoo surveyed regions, bypassing the need for further expert crater count validation exercises.

5. Summary and Conclusions

The Moon Zoo project is poised to deliver high quality data to address key questions in lunar science in the peer-reviewed literature. At the same time, Moon Zoo is an excellent education tool to help promote lunar science and exploration and engage the public in learning about the process of scientific discovery.

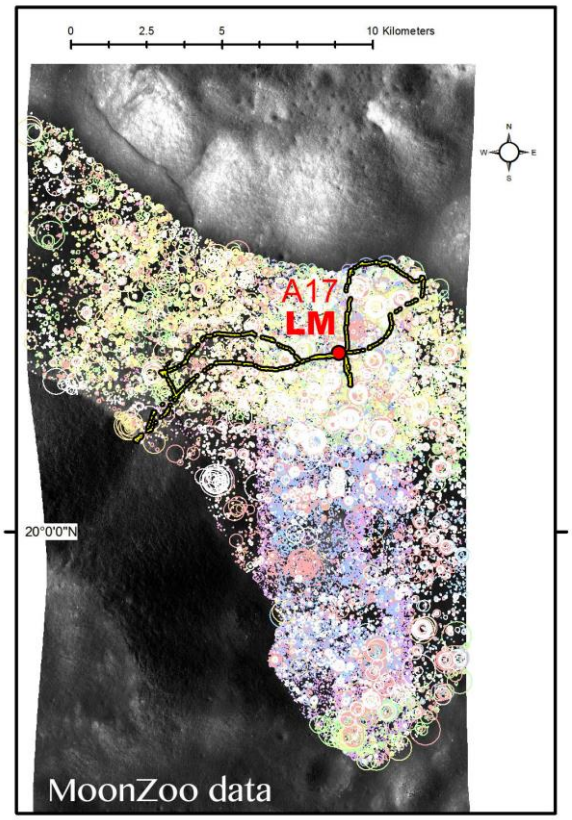

Figure 1. Moon Zoo crater data of the Apollo 17 Taurus-Littrow valley region. Different colours denote different NAC sources. Base map LROC M104311715.

References

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