MOON ZOO: UTILIZING LROC LUNAR IMAGES FOR OUTREACH AND LUNAR SCIENCE.
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Introduction: Moon Zoo will be an online lunar citizen science project. It is one of the latest incarnations of the highly successful Galaxy Zoo project (http://www.galaxyzoo.org/), which harnesses the power of the Internet to classify galaxies to support astrophysics research.

In the first instance, Galaxy Zoo users were presented with ground based telescopic images of almost a million galaxies, given the choice to classify their shape and — if the galaxy was a spiral — record the rotation direction of the arms. Using the data the project provided, the Galaxy Zoo science team was able to prove that the citizen classifications were as good as those completed by professional astronomers. In the words of the Galaxy Zoo team "In fact, the Galaxy Zoo data has an advantage over traditional expert classification; obtaining a large number of multiple independent classifications allows the team to quantify the uncertainty in their results."

Numerous papers have been published [e.g. 1-4] using the Galaxy Zoo database to address key questions about the formation and evolution of galaxies, and to follow up on serendipitous discoveries of new and unusual celestial objects made by Galaxy Zoo users.

The second Galaxy Zoo project (Galaxy Zoo 2) has just been launched, and within the first two months of operation has received over 220,000 registered users completing 27 million individual user classifications.

The Moon Zoo Concept: Moon Zoo, due to be launched in late summer 2009 (initially with archive data), will be a similar online citizen science project that will ask users to identify, classify and measure the shape of features on the surface of the Moon using a specially designed graphical interface. The interface will be available in several languages to ensure that this is a truly international lunar science project.

Moon Zoo Outreach Potential: We expect Moon Zoo to be even more popular than Galaxy Zoo in engaging the public with modern day space exploration. The Moon captures the interest and imagination of all generations as it is seen as a constant presence in peoples' lives and it is therefore accessible to everyone. We plan to tap into this awareness by providing a free and easy to access device for studying the Moon's surface, whilst harnessing this user power to conduct high quality lunar science.

Moon Zoo Data: The project will initially utilize PDS released high spatial resolution images (with associated metadata) from NASA's Lunar Reconnaissance Orbiter Camera (LROC) instrument, which is due to be launched on the LRO mission in June 2009 [5].

Statistical analysis of the Moon Zoo user data will allow us to address interesting lunar science topics, and will also aid the planning of future exploration of the Moon by robotic and manned missions.

Moon Zoo Science Case: The Moon Zoo lunar science team has identified three preliminarily Moon Zoo user projects [6] that can be readily addressed by registered Moon Zoo users utilizing LROC data. These projects address a variety of important lunar science and exploration themes [7], and are briefly described below:

Project 1a. Count the number of and measure the dimensions of impact craters on the Moon (yielding both crater diameter and ellipticity) with the aim of improving the precision of lunar crater counting statistics. Crater counting allows us to calculate the apparent age of the lunar surface, by comparing the number of impact craters on different lunar surfaces (i.e. lava flows, crater ejecta blankets etc.). Technical issues such as classifying primary vs. secondary craters are beyond the scope of user classification tasks and so will form an important component of subsequent database exploitation and scientific interpretation.

Understanding the age of different lunar lava flows and crustal surfaces will shed new light on the temporal thermal and magmatic history of the Moon, and will have important implications for understanding heating processes of small rocky planetary bodies.

Project 1b. Users will also be asked to assess a scale of blockiness state (ejected boulder concentration) of crater rims, to classify them and help to determine local regolith thickness variation [8].

We will also ask Moon Zoo users participating in both Project 1a and 1b to identify, and therefore catalogue, the location of interesting lunar features such as lava channels (rilles), crater chains, lava flooded impact craters, volcanic eruptive centers (pyroclastic deposits), volcanic domes and unusually shaped craters within the scale size of the LROC images, for further analysis by the science team.

Project 2. Users will assess the degree of boulder hazards on the lunar surface by comparing two images (of similar scale at similar illumination conditions), and identifying the one with the higher boulder density. These results will produce relative boulder density hazard maps to help identify the most suitable locations for sending future robotic and manned missions to the Moon.

Project 3. Identify recent (in last 40 years) changes on the lunar surface by comparing new LRO images with older Apollo photographs (of similar image resolution and illumination conditions). We hope to identify the locations of recent impact craters or landslides or even volcanic eruptions [9,10] on the lunar surface.

By counting the number of 'new' impact craters we can calculate the current impact flux rate of the Earth-Moon system, which is of great interest for assessing the risk to humans from asteroid and meteoroid impacts and to help constrain planetary chronology based on impact crater counting.

All Moon Zoo Projects: Moon Zoo users will also be asked to identify the location of space mission hardware on the Moon (i.e. Apollo lunar landers, Russian Luna rovers, crashed US, European and Chinese probes and rocket stages etc.), to build up a database that can be made available to the worldwide science community to be used as positional landmarks for lunar cartographic mapping.

Moon Zoo Current Status:

Science Team and Goals: The Moon Zoo Science Team is being assembled and we are refining our project goals through discussion within the team and with the LROC Science Team.

Software: The Moon Zoo software database 'back-end' is being developed by the team at Oxford University, based on their experience with storing and analyzing large amounts of citizen science data. The 'front-end' user interface is being designed to fulfill the science goals and development will be in progress over the next few months, once the science projects have been finalized.

Outreach and public engagement: Lunar science outreach information and links on the Moon Zoo website are being developed by a team led by Pamela Gay (Southern Illinois University Edwardsville). The Moon Zoo team is also working closely with Adler Planetarium to promote the project through their 'Moon Wall' interface and other outreach activities.

Website: The Moon Zoo website will be tested with PDS released Apollo image data and then will go live with PDS released LROC data as soon as this is available. User data will be assessed and software updates made accordingly after the website launched. Moon Zoo lunar science database mining and scientific interpretation will begin approximately six months after going live.

Validation: The Galaxy Zoo project utilizes a variety of statistic analysis tools to study the quality of user classifications (i.e. how often they get the 'correct' answer compared to an expert classification; how varied the classification result is between users; identification of potentially malicious classifications etc.). Similar tools will be employed for exploiting the Moon Zoo user databases.

A variety of data reduction techniques will be employed to turn raw data collected by the Moon Zoo website into science-ready outputs. For example, it is possible to 'weight' users according to their degree of agreement with expert classifications (or other results), and then iterate these results through the database. This technique has proved to be effective in obtaining high fidelity results even for apparently difficult citizen science tasks [1-4].

We also expect the validation process to produce additional science results in itself, for example, analysis of the standard deviation of the crater diameter histogram can help to reveal craters with degraded rims through slight variations in user measurements, because these will be the most difficult to measure.

Concluding Statement: All new Zoo projects must be capable of delivering peer-reviewed science. Moon Zoo is poised to do just this by providing high quality data to address key questions in lunar science. At the same time, Moon Zoo will be an excellent outreach tool to help promote lunar science and exploration and engage the public in learning about the process of science discovery.

The Moon Zoo Science Team, welcome comments and feedback from the lunar science community on the project science goals defined in this abstract.

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