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Textural Analysis to aid Automated Classification of Lunar Craters

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Abstract

With the advent of many Terrabyte size image datasets of the Moon, it is no longer possible for the lunar science community to manually count and classify all the available lunar craters. We discuss the use of automated feature recogniton and textural analysis techniques to assist in a solution to this problem.

1. Introduction

Craters that are formed from projectiles impacting the Moon are of great interest to lunar scientists. Craters constitute a large proportion of the lunar surface area and have exposed material from beneath the lunar surface and redistributed this in ejecta patterns surrounding each crater [5]. Furthermore, due to the Moon's stable, less varied surface processes (compared to the Earth), the lunar surface contains a record of impacts over the last 3 b.y. which gives us an insight into the cratering history of the Earth and solar system. The most recent lunar mission is the Lunar Reconnaissance Orbiter which is equipped with the Lunar Reconnaissance Orbiter Camera (LROC). In the first six months of operation LROC has returned over 100,000 ~50cm resolution images of the lunar surface totaling ~10 Terrabytes thus highlighting the need of automated techniques to process this vast amount of data.

2. Methodolgy

The work presented in this paper expands on previous work conducted using machine vision techniques to classify lunar craters [4]. This methodology involves image region modeling techniques on segmented images in order to create a hierarchical data structure for the display of large quantities of self similar textures.

2.1. Weighted Texton

Many models exist that analyse texture [7]. The Texton approach introduced by Caelli and Julesz [2], made operational by Leung and Malik [6], provides a model that is both computationally tractable applicable to heterogeneous image data.

Unlike Texton techniques that rely upon pre-trained texture dictionary, such as the Leung and Malik [6] methodology, the weighted Texton model (WTexton) proposed by Gibbens has no such reliance [4].

The Texton method proposed by Leung and Malik [6] involves filtering a series of textures to create a model. These responses are then clustered and the vector quantized filter responses to this model are used to create train a dictionary (e.g. the CUReT textural database [3]). Given a 'novel' texture, its response to the model is then compared to the dictionary and thus identifying its closest training class.

A WTexton requires each texture to be filtered and clustered to produce a set of vector quantized filter responses. This was achieved by using a cluster analysis methodology such as K-mediod or agglomerative clustering, and results in the creation of a Texton set which was then compared to other sets without the need of a pre-trained dictionary.

2.2. Taxonomy

There is much research available which discuss the optimal way that humans can view large quantities of image data [1]. A taxonomy is a way that one can structure objects within an image in a meaningful way. Hierarchical clustering, such as the agglomerative clustering technique, provides a level of similarity as a series of subsets (Figure 1). A taxonomy of image regions is created thus aiding undirected browsing.

3. Lunar Reconnaissance Orbiter Camera data

The LROC is an instrument on board the Lunar Reconnaissance Orbiter (LRO) which was launched in June 2009 and contains a narrow angle camera (NAC). For our initial tests we have segmented manually the data to encompass the target crater (Figure 2). Using the WTexton method previously outlined in 2.1 a series of clustered filter responses have been calculated

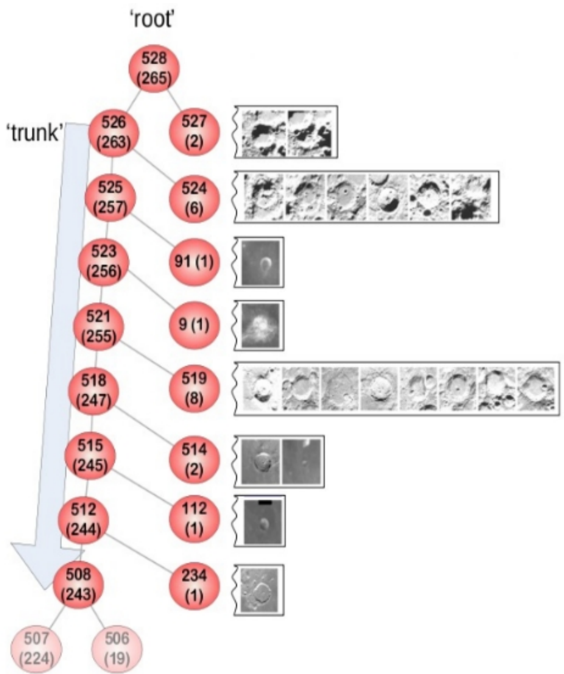

Figure 1: A Progression of clusters from the root of the taxonomy, cluster IDs shown with cluster size in parentheses.

from several crater images which can then be compared with one another in order to create a taxonomy as described in 2.2.

4. Initial Results

While still in the early stages of development, we have been able to demonstrate the Texton analysis technique for a small set of images and we are currently analysing the CUReT textural data base [3] for comparison with previous methods of classification for a measure of classification accuracy.

5. Summary and Conclusions

This work so far has demonstrated the potential benefits of a system based upon textural analysis. Image segmentation will play a very important role in the overall quality of a resulting taxonomy. Work is currently underway to produce a taxonomy of crater classifications for a large set of data in the coming months.

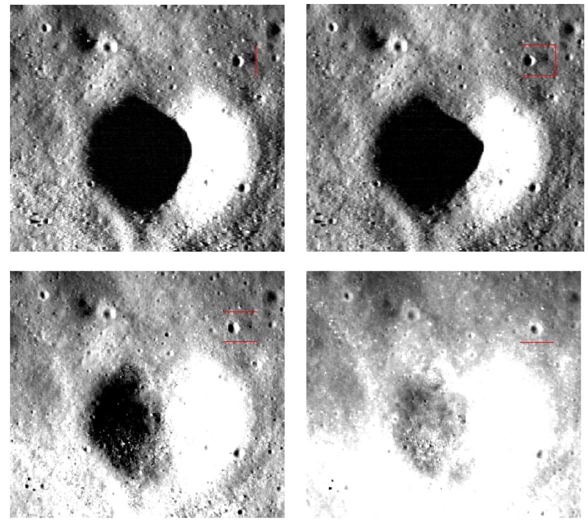

Figure 2: Four LROC-NAC images taken of the same crater at different view and illumination angles

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