Copernican and Eratosthenian Craters

Automated Classification from Normalized Reflectance

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Introduction

Why?

We want to understand the impactor flux history of the inner Solar System.

Why the Moon?

By quantifying changes in the Moon’s crater production rates and their spatial distribution we can infer the conditions of Earth’s space environment through time.

Why automation?

There are LOTS of craters on the Moon; classifying the relative ages for all craters on the Moon is a daunting task, albeit a very important one.

Current Paradigm

<table>
<thead>
<tr>
<th>Name of System</th>
<th>Billion Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernican</td>
<td>1.1 to present</td>
</tr>
<tr>
<td>Eratosthenian</td>
<td>3.2 to 1.1</td>
</tr>
<tr>
<td>Imbrian</td>
<td>3.85 to 3.2</td>
</tr>
<tr>
<td>Nectarian</td>
<td>3.9 to 3.85</td>
</tr>
<tr>
<td>Pre-Nectarian</td>
<td>4.5 to 3.9</td>
</tr>
</tbody>
</table>

The recent impact history of the Moon is preserved and observable as craters with high reflectance rays [1], called Copernican craters (see Figure 1).

With continued exposure to space weathering [2], the bright crater rays will darken, their reflectance acquiring the same value as the local background [3]. These craters are called Eratosthenian craters (see Figure 2).

Methods

Objective: create a robust database of crater ages to compare automated classification results.

1. 926 craters located between latitude range -50° to 50° were randomly selected from LROC’s 5-20 km crater database [4].

2. Craters were manually classified using LROC WAC 643 nm 100 m/pixel photometrically normalized reflectance map [5] and WAC 100 m/pixel global morphologic map according to the following criteria:
   - Copernican: observable rays and crisp morphology
   - In-between: faint rays, and crisp morphology
   - Eratosthenian: no observable rays but crisp morphology
   - Old: degraded craters
   - Unable to Classify

Results for manual classification:

<table>
<thead>
<tr>
<th>Name of System</th>
<th>Mare</th>
<th>Highlands</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernican</td>
<td>6</td>
<td>86</td>
<td>92</td>
</tr>
<tr>
<td>Eratosthenian</td>
<td>11</td>
<td>98</td>
<td>109</td>
</tr>
<tr>
<td>Ambiguous</td>
<td>24</td>
<td>56</td>
<td>80</td>
</tr>
<tr>
<td>Older</td>
<td>24</td>
<td>27</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>155</td>
<td>247</td>
</tr>
</tbody>
</table>

Results for semi-automated method:

Preliminary test documented in our abstract using 40 craters from Wilhelms’ database showed correct detection efficiency of 90%.

Used same crater list that was used for manual classification, and extracted mean reflectance values of 40 concentric rings about the center of each crater. Average values of the rings between 0.5R and R, and 2R to 3R are used in our classification.

Rationale

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References: