Measuring Sizes and Distances on Mars using *ImageJ*

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Abstract

ImageJ is a public domain Java image processing program (developed by NIH) that can display, edit, analyze, process, save and print 8-bit, 16-bit and 32-bit images in almost any format. It can calculate area, pixel value statistics, distances, and angles and can perform geometric transformations, such as scaling and flips. I use *ImageJ* to teach students how to interpret a CCD image of a planetary surface realistically, and it would be a great tool for understanding and interpreting Mars images.

Introduction: Prelab

Students are given a pre-lab that must be completed before they come to the lab. This pre-lab introduces students to the way astronomers can take and store images in digital form (CCDs; Figure 1) and how they extract information about surface features of objects in the Solar System.

Students are also encouraged to simulate an image-processing program by displaying a digital image on a grid. They do this by shading-in each pixel of the image according to the **L**ook**U**p **T**able shown underneath the grid. While time-consuming and difficult for students with dyslexia, it does help them understand how pixels are assigned brightnesses and colors and how these parameters affect image quality.

They are then asked to define terms such as LUT, pixel, brightness, contrast, and "false-color" image.
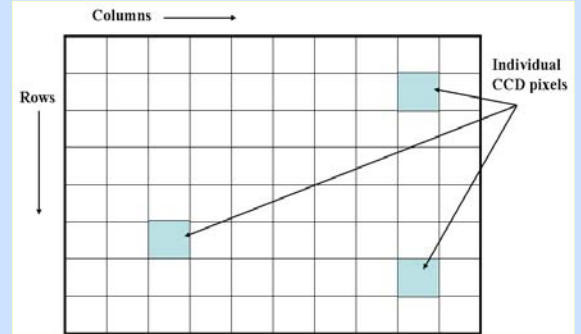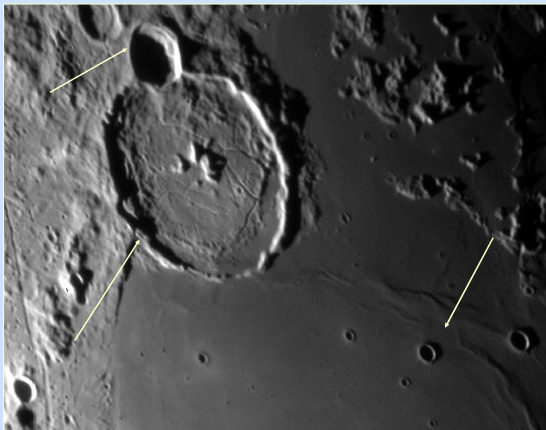

Figure 1. An example of a CCD array.

Figure 2. Lunar craters. Which is the youngest?

Understanding Superpositioning and Sizes

Students are given an image with several lunar craters (Figure 2), and they must arrange the craters in order of increasing age. This proves a little difficult if the concept of bigger objects hitting objects earlier on in Solar System history has not been discussed.

Finally, we can demonstrate the idea of surface density by counting the number of craters in a certain area and using that information to estimate the total number of craters on the Moon. Simple math, but the number never fails to astound students! $\rho = 0.016$ craters/km^2, R = 1738 km

Now that students are familiar with terminology, they use *ImageJ* to understand Solar System images. They analyze images to determine pixel values (max and min), then brightnesses (colors) and sizes.

Using *ImageJ*

Students can use pixel brightness to determine in which lunar phase a lunar image was taken. They can also determine the sizes of objects in pixels and use a conversion factor to determine the sizes in meters/km/etc. Using the "plot profile" option, they can scan across an image to determine brightness variations, and in the case of Saturn's rings, where the gaps (arrows) and ringlets are (Figure 3).
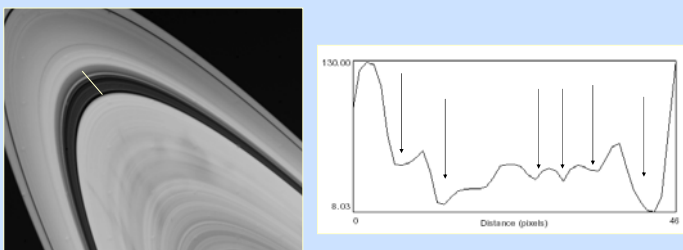

Figure 3. Saturn's Cassini Division density profile.

Conclusions

I think this program is very versatile and can be used to determine distances and sizes on Mars using images and data from all of the Mars instruments.

Comments: