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Visualization of the shape index profile of a 2D Astronomical image in 3D

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ABSTRACT

Astronomical data provides assertions about the natureof life. This paper focuses on data and noise reduction of the provided Moon fit files, to analyze themountains on five different terminator positions of the Moon. Autostakkert and ds9 tools are used respectively for noise reduction as well as pixel distance calculation. The main focus of this paper is to provide 3D visualization of the shape index profile of the input image using python script.

Keywords: *Autostakkert, ds9, Shape Index, Noise reduction, Terminators, Astronomical, Python script, Astronomical Data*

1. INTRODUCTION

The gathering of images and data from various planets,stars, and satellites may aid in the discovery of the three essential ingredients of life. Mars was discoveredto have an abundance of chemical building blocks, liquid water on its surface, and a source of energy (volcanic activity) to power the chemical reactions that allow life to exist. As the Earth's resources dwindle, alternate possibilities to sustain life have to be figured out.

The Shape Index represents the compactness of the shape of the planet. Many Scientists use shape index as a standard for measuring 2D Data. The formats can be very important to study more about Astronomical Dataand can also be used to do more research on the surface of various planets, stars, and satellites

In this paper we would be analyzing the heights of mountains on the moon and compare them to real datato verify the results. The process demonstrated in the paper could be applied to help scientists and data analysts identify different features on Planets that are yet to be discovered to interpret the possibility of life. 3D Wire grid format of the input image has also been developed, which is crucial to understanding the Astronomical Data better.

Fig 1(a): Tiff of Terminator 1 position of theMoon

3D Visualization:

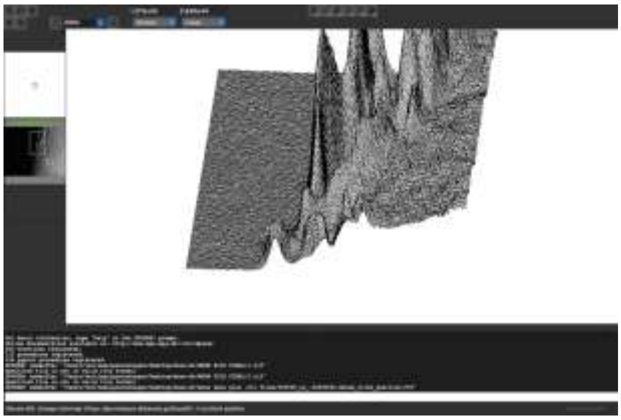


Fig 1(b): Wire-grid visualization of Terminator 1position of the Moon

2. RELATED WORK

[1] The Markov chain monte method discussesthe solution of resolving the problems in Bayesian data analysis astronomy.
[2] The Science data visualization in planetary contexts presents a 3D orbit viewer application todisplay science data.
[3] Removal of Noise by Median filtering describes three types of noise filtering techniques.

[4] Visualization and Nomenclature for planetary maps are highly crucial for the visualization of planetary surfaces.
[5] Shape index analysis is applied to analyze the Texture descriptors of planetary structures. Image Gradients are the fundamental building block of any digital image which represent a directional change in pixel intensity or contrast levels. Gradient Computation is a high-priority task for many post-processing image processing techniques including edge detection and segmentation. Mathematically, Image Gradients are computed in the following way:

$$\nabla f = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

3. SHAPE INDEX ANALYSIS

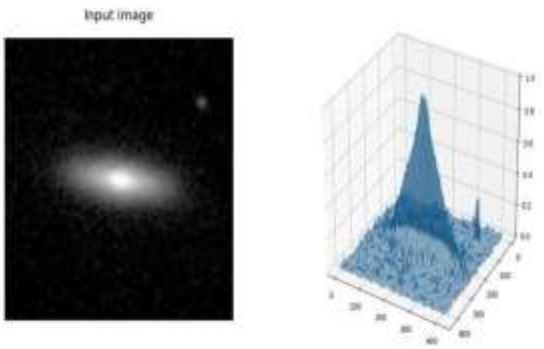


Fig 2(a): Original Input File.

Fig 2(b): 3d visualization of shape Index profile of theInput Image
Fig 3(a): Original Input Image with Extrema Analysis.Fig 3(b): Dimensional visualization of shape index profile of the Input Image. (c). Shape Index with σ = 1.

Image Gradients

Fig 4(a): Original Image. (b): GradientMagnitude of the Image. (c): Gradient Orientation in HSV colormap.

[6] ImageJ's image processing skills are valuable in a variety of scientific domains and can be extended. AstroImageJ (AIJ) is a program that provides an astronomy-specific image display environment as well as tools for image calibration and data reduction. AIJ is streamlined for time-series differential photometry, light curve detrending, and fitting, and light curve charting, especially for applications needing ultra-precise light curves (e.g., exoplanet transits). AIJcan read and write standard Flexible Picture TransportSystem (FITS) files as well as other common image formats, displays and edits FITS headers and is WorldCoordinate System aware, including an automated access to the astrometry.net web portal for plate solving photos.

4. DATA COLLECTION

The Gratama telescope of the Blauuw observatory, located on the top of Bernoulliborg in Zernike Campusis a 40 cm reflector telescope. The images were captured by the smaller planetary camera, equipped with a CCD sensor with a plate scale of 0.763 arcsecs/pixel. For this project, a set of data was collected using the bias, dark, and flat frames. The point of observation was determined by the internal guider camera.

For each of these calibration files, we observed the length of the terminator of the moon, in 5 sets. Hencewe have terminator positions 1,2,3,4 and 5. The telescope captured hundreds of images per position, atechnique called lucky imaging. This data was analyzed and a master dark, biased, and normalized flat image was made for each filter.

The process of observing and capturing images via lucky imaging to study features is also applicable to other planetary bodies. With the appropriate filters, high-resolution images of planets, as well as the Sun,can be captured.

Lucky imaging also reduces the possibility of error that could arise from an external object falling in theview of observation, due to the large amount of datacollected (precisely 582 fit files were obtained).

5. PROPOSED METHOD

Pre-processing of the data is performed in two stages;Data-reduction and data to image conversion. Data reduction is implemented using a python script.

Flexible and Interoperable Data Transfer file, which provides GPS details about planetary structures, is reduced and converted to image format for visualization using python scripts. Graphical visualization of craters and mountains on the Moon isproduced.

Reduction of noise and stacking of similar images is achieved using the Autostakkert tool. This tool helps align several images from the same terminator position, based on similar characteristics shared by all the images. This process helps define the features more prominently in the resulting final image. The achieved images are referenced with the Virtual Atlastool, to acquire the names of the craters and mountains. Heights of the Mountain on the Moon is computed in the following manner:

Pixel distance between the tip of the mountain to the end of the shadow is calculated using the standard distance formula, where (x1,y1) are coordinates of thetip of the mountain and (x2,y2) is off the edge of the shadow:
Distance formula: d=√(x_2-x_1)^2 - (y_2-y_1)^2

Tan(Φ)= 0.763(The angle between the terminators and the earth) * calculated distance

Calculating height: Tan(Φ)= h / (Distance betweenearth and Moon)

The pixel distance is computed using the contour-gridframe provided by ds9 tool (Fig 4(a)).

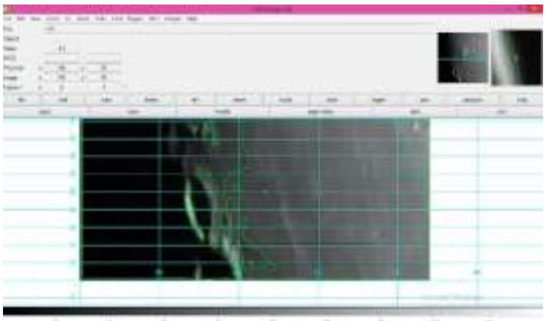
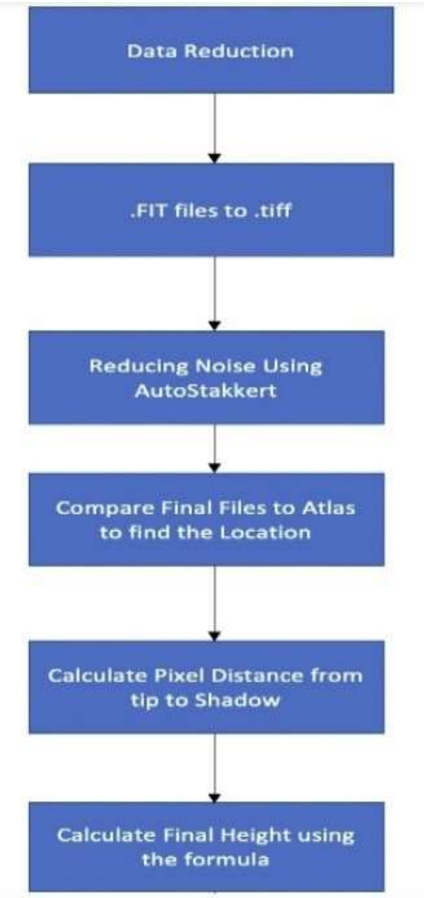


Fig 5: Ds9 tool to calculate pixel distance between thetip of the Mountain and the end of the shadow

6. PROCESS FLOW DIAGRAM



7. CALCULATIONS

TERMINATOR POSITION 1

Feature	Measured Height	Location	Literature Height
Cavalerius	1.2 ± 0.2 km	5.1 N, 66.8 W	1.3 ± 0.2 km
Reiner	1.5 ± 0.5 km	7.0 N, 54.9 W	0.9 ± 0.1 km
Luna-9	1.4 ± 0.3 km	8.0 N, 65 W	1.3 ± 0.2 km

TERMINATOR POSITION 2

Feature	Measured Height	Location	Literature Height
Vico A	1.2 ± 0.2 km	5.1 N, 66.8 W	1.3 ± 0.2 km
Primae Darwin	1.5 ± 0.5 km	7.0 N, 54.9 W	0.9 ± 0.1 km
Cruger south	0.7 ± 0.2 km	18.6 S, 67.0 W	0.6 ± 0.1km

TERMINATOR POSITION 3

Feature	Measured Height	Location	Literature Height
Damoiseau A	1.8 ± 0.3 km	6.3 S, 68.88 W	1.9 ± 0.1km
Sirsalis Z1	2.3 ± 0.3 km	10.0 S, 60.0 W	2.3 ± 0.4 km

TERMINATOR POSITION 4

Feature	Measured Height	Location	Literature Height
Damoiseau-F	2.3 ± 0.7 km	8.5 S, 63 W	1.9 ± 0.2km
DamoiseauJ	1.7 ± 0.8 km	3.5 S, 61.5 W	1 ± 0.2km
Close to Lohrman	1.3 ± 0.2 km	0.5 S, 66.8 W	1.6 ± 0.1km

8. 3D VISUALIZATION RESULTS

The following output is the result achieved usingpython script.

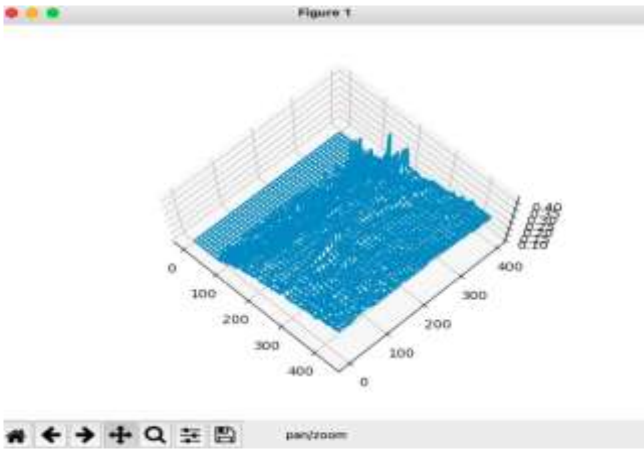


Fig 6: Wire Grid Format using python script

9. CONCLUSION

One of the main purposes of this paper is to identify and detect Craters and Mountains on the lunar surface,and to also provide 3D visualization of 2D images; to analyze the surface better. The other goal is to develop immersive visualization and analysis tools that increase planetary information. We will also continue to improve the toolset guided by the needs of real-world geoscience research questions.

The process of observing and capturing images via lucky imaging to study features is also applicable toother planetary bodies. With the appropriate filters, high-resolution images of planets can be captured.

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