Sunspot Data Extraction Using 3D Isophote Rendering

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Abstract

The paper explores the use of three-dimensional isophote rendering from ImageJ to be used to analyze sunspot groups and extract sunspot count data and structural features. This technique allows increased accuracy in acquiring the Wolf number even with the use of low-resolution image data.

Keywords Sunspot Count Isophote Sunspot Groups Image Analysis

Introduction

The relative sunspot number (Wolf number) is one measure of determining the solar activity. It was established by Rudolf Wolf over 150 years ago. The relative sunspot number R is computed by identifying the number of visible sunspot groups g and the net sunspot count from all groups s.

$$R = 10g + s$$

For periods when the Sun is active (approaching maxima) there is a rise in the frequency of sunspot groups, and the reverse for periods when the Sun is inactive (minima).

The difficulty of sunspot counting, however, lies in the difference of each individual's independent count. A number of factors increase the amount of uncertainty in one's data: experience, seeing conditions, 24-hour counting period, equipment, resolution, pore-spot distinction, ranges in tonal gradation.

With the onset of the digital photography it is now possible to limit the difficulties of making sunspot counts. One such photographic technique is the creation of isophotal images. Isophote rendering is a useful tool in extracting undiscernable sunspot features in which areas are separated by density.

ImageJ

The software ImageJ was developed by Wayne Rasband of the National Institutes of Health, USA. It is an open source program that can be downloaded on the internet at http://imagej.nih.gov/ij. The program runs on a java platform and can be used to process and analyze images. Among its plugins is the rendering of a 3D plot from the image data.

Sample Observation

This image analysis form is supplemental to regular sunspot observations. Here is a whole-disk image of the Sun taken on April 17, 2014 showing 10 active regions. The image is taken using a Nikon

D3100 mounted on a 6-inch Newtonian reflector (Sky-Watcher Explorer 150PL) at prime focus and with a full-aperture Baader AstroSolar Safety Film.

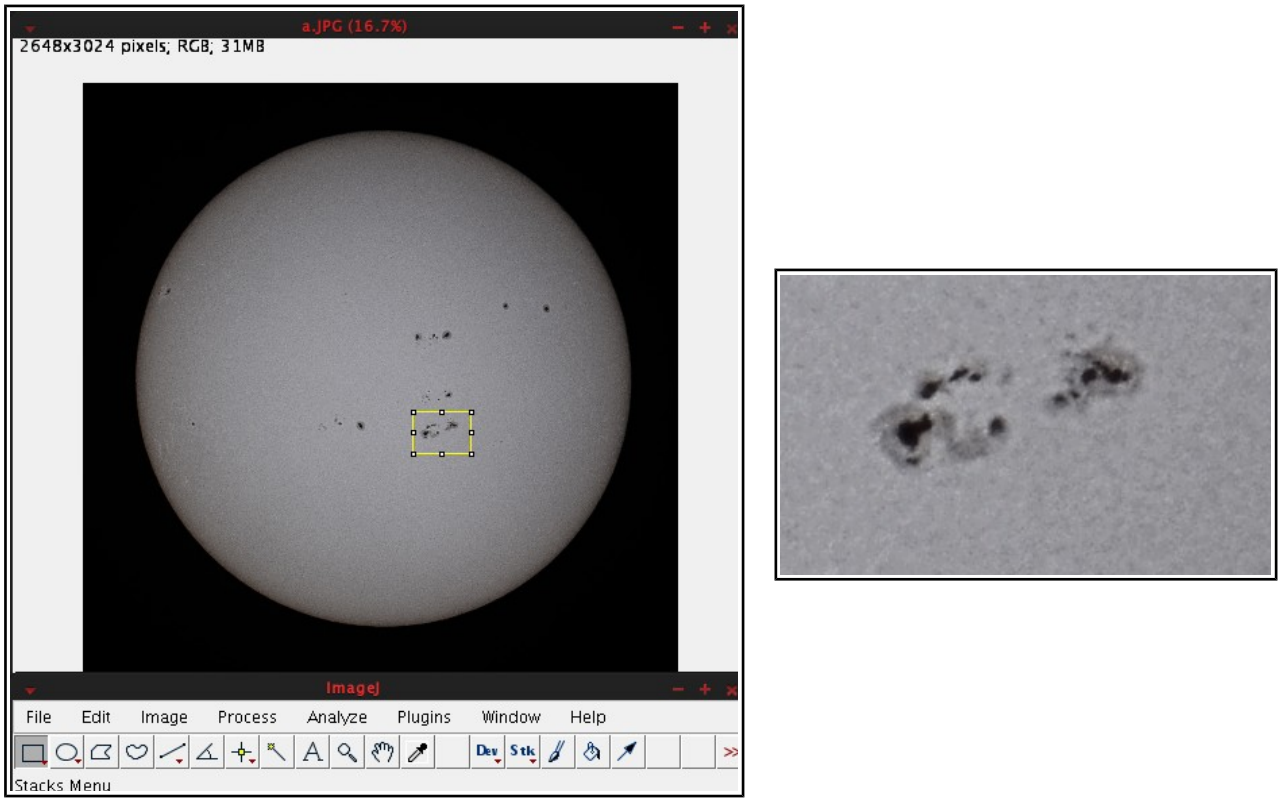

Figure 1. Solar Image | 17 April 2014
AR 2036 selected from a whole-disk image in ImageJ; and AR 2036 cropped

We select a particular active region for analysis (AR 2036). From the Plugins tab you can access the interactive 3D surface plot to do your isophotal analysis. There are a number of features in the plot that allows you to see your image isophote differently. To give it a solar surface look I set the plot to Filled and Fire LUT.

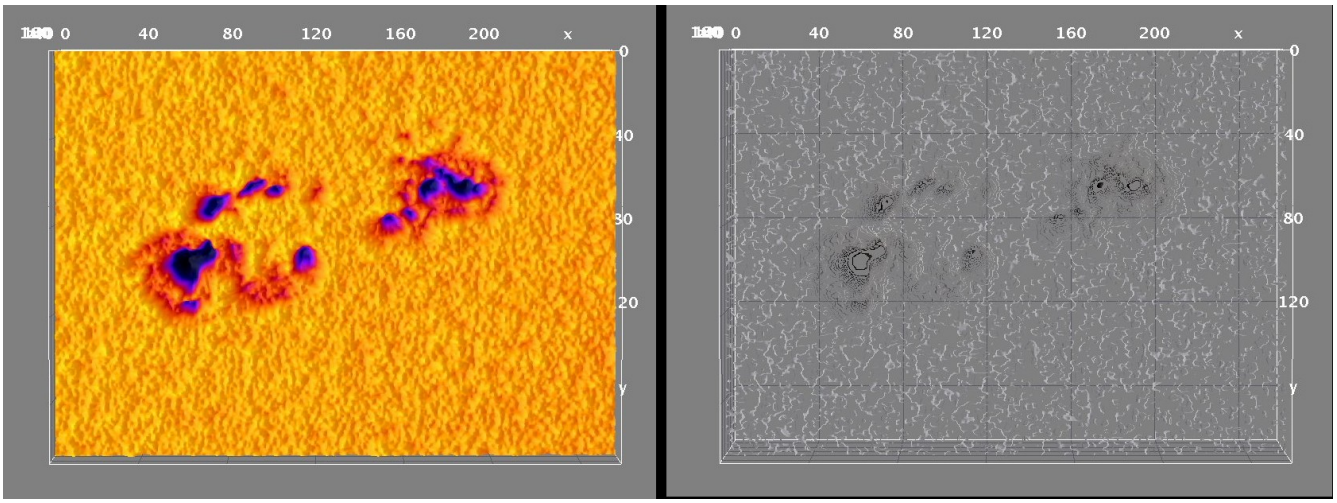

Figure 2. Interactive 3D Surface Plot
Different looks that can be rendered from the image plot. The left in Filled and Fire LUT, right in Isolines and Original colors.

The plot brings out details that are hard to detect from the original image such as better contrast to granular cells as well as faint spot features. The plot can be fully rotated and the depths of the different density areas changed to bring out other detail (Figure 3).

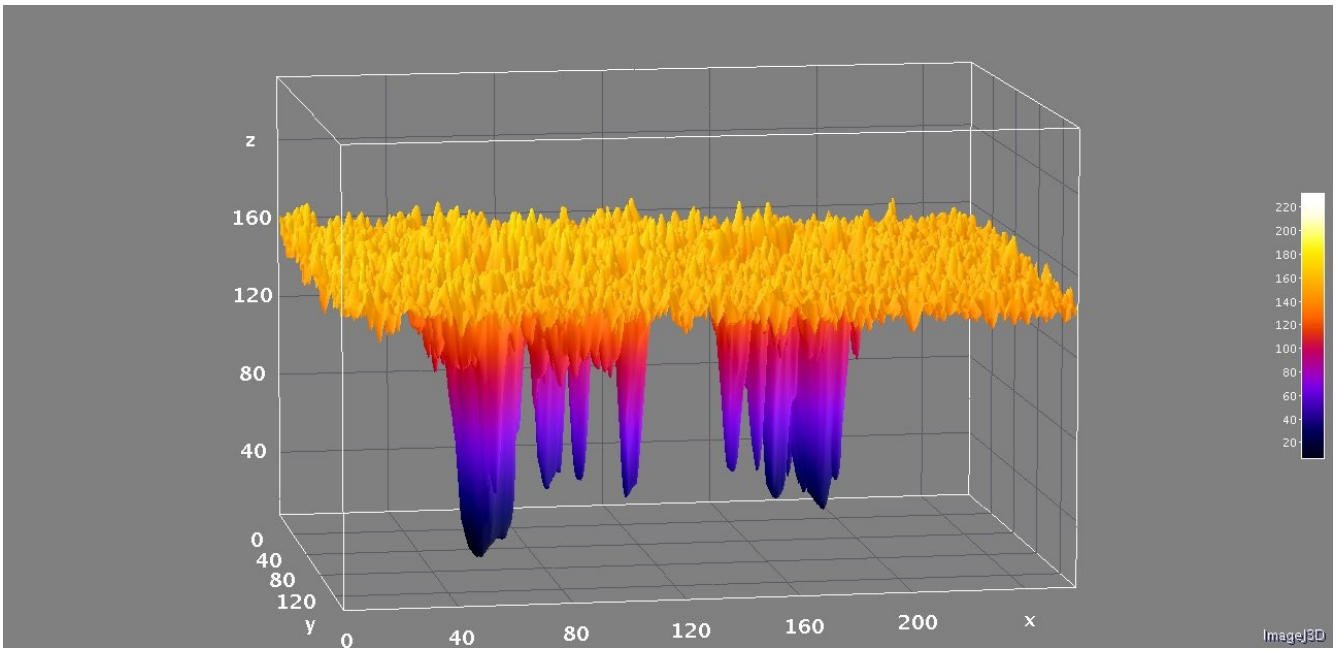

Figure 3. Rotated Surface Plot of AR 2036

The sunspot count of AR 2036 from the original image is 42 but using the 3D surface plot and tweaking the density levels revealed 14 more spots making the count 56. The counting is also made easier since the image has better contrast from the original.

Other photographic methods rely on image processing to enhance light features but the risk is that the darker umbral features are lost. The interactive 3D surface plot allows both the dark and light features to be made out without loosing image data. This tool's ability to make out features also allows for better estimation of sunspot activity even for low-resolution images (Figure 4).

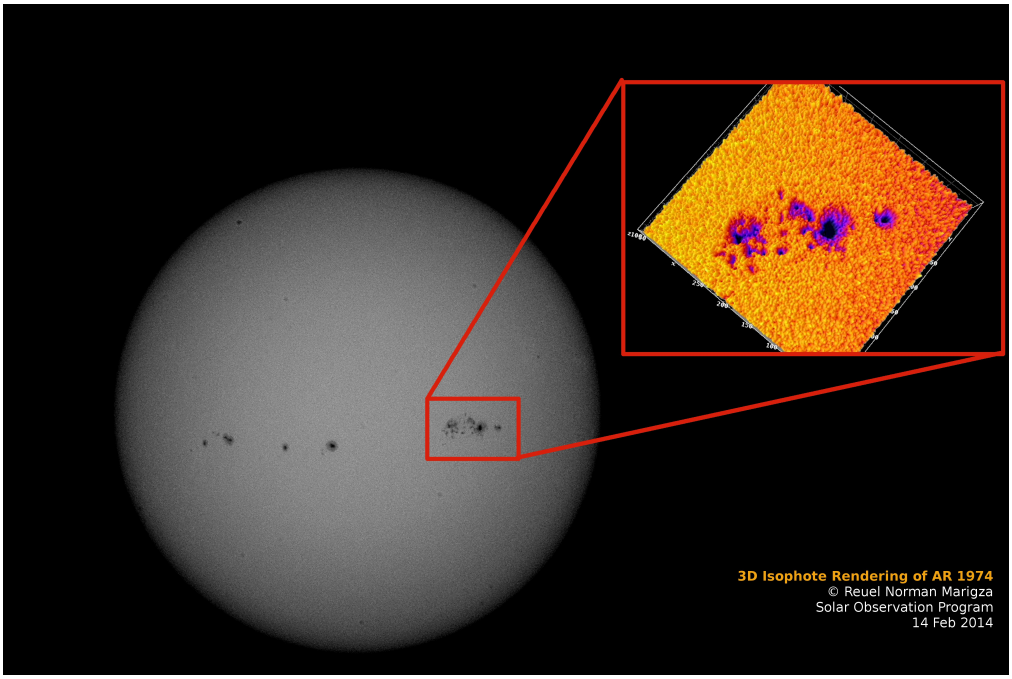

Figure 4. 3D Isophote Rendering of AR 1974 from Low-Res Image
Whole disk image taken with a Nikon D3100 and Baader filter on the aperture stopper of a Sky-Watcher Explorer 150 PL.

Conclusion

The interactive 3D surface plot function of ImageJ is a useful isophotal tool in discerning sunspot features that are usually hard to see or bring out through conventional image processing methods. The availability of this software makes this image analysis tool accessible to everyone who wishes to improve their sunspot data.

References

Bray, R. J. & Loughhead, R. E. (1962). Isophotal Contour Maps of Sunspots. Australian Journal of Physics. 15(4) 482-489.

Jenkins, J. L[1]. (2003). Techniques for Viewing Sunspot Umbrae with Isophotes. The Strolling Astronomer. Association for Lunar and Planetary Observers. Vol 45, No. 1.

Jenkins, J. L[2]. (2009). The Sun and How to Observe It. Springer: New York.

Rasband, W. ImageJ. National Institutes of Health, USA.