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Image Processing in Amateur Astro-Photography

Using low cost apparatus to perform astrophysical research at school level.

Introduction

The contribution by amateurs to research in the field of observational astronomy has been known from several centuries, which is a motivation for amateurs of today to get into research. In the recent times sophisticated techniques have caused a revolution in photography. In this article we discuss some of the aspects of image processing techniques that can be used on the images taken by the amateurs/students using simple imaging instruments like a digital camera or a webcam and the kind of useful astrophysical results that can be extracted using these techniques.

Amateur Astro-Photography

The beauty of the universe is mesmerizing and it is a challenge for amateurs to grab its beauty on the camera. Digital cameras, DSLR cameras or the CCD/CMOS-based webcams are very popular. Using these instruments with a telescope of reasonable size and tracking can produce good results. They can capture the charming nebulae even with an altazimuth mount by adjusting the exposure time to avoid any field rotation. An amateur at work can thrill any layman as well as a professional. Amateurs work with all the professionalism possible, select their source, look for the best possible time of the observation and carefully select the location to optimize visibility of the source and light pollution. They have an added advantage over the professionals, because of their ability to be on the move to catch any desired event or source they are fascinated with, not bounded with the limitation of an observatory. One of the most useful tools to reveal hidden features of a source is 'stacking'. Professional software is available which can be used to extract frames from a movie file made using a webcam and then stack those images to give the quality equivalent

Keywords

Astronomy, Astrophotography



to long exposure images even with a small telescope with no tracking.

Image Processing

The technique of image processing used by amateurs differs from that employed in large observatories. Amateurs stack images by adjusting brightness and contrast whereas professionals do a detailed procedure of eliminating background count and then extracting surface brightness, magnitude, and polarization and so on. Some of the softwares used are IRAF, fv, DS9 and languages like FORTRAN or C and C++.

The biggest limitation that an amateur faces when he thinks or even tries to extract numbers out of images is that none of these softwares can read a jpeg, raw or any other popular image format but only fits (Flexible Image Transfer System). Another problem is the dependence of these softwares on Linux or Mac OS. But this is not very severe, because softwares like DS9 and fv have been successfully ported to windows and also most of the amateurs use Linux and Mac OS.

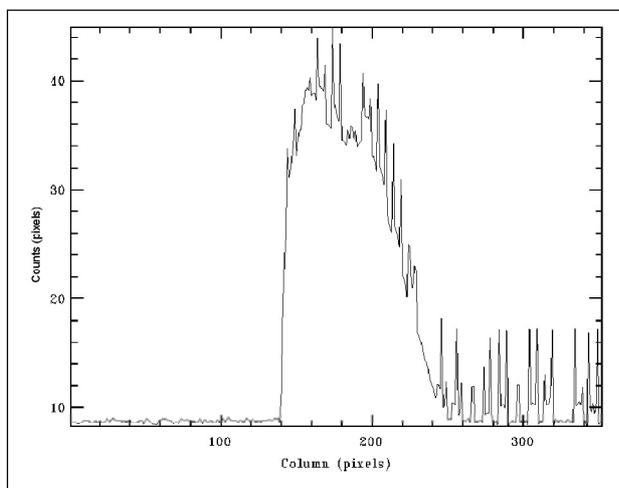
Analysis of Lunar Eclipse Images

We had about 120 images (all in jpeg format) of the February 2008 lunar eclipse taken through a webcam, which we had saved from a web cast, and we had to figure out some way to convert them into fits format. The most efficient method we found was by making use of a routine provided by NASA that can be used with Image Magic [1], that can easily convert jpeg to fits. GIMP can also do the same task very easily. IRAF facility [2] can be extended to gif images also.

Our main aim for the analysis was to extract the exact time of commencement of penumbral eclipse. We had to evolve a method of recognizing the start of the penumbral eclipse. We expected it to be visible as a variation of Moon's surface brightness. We aimed at measuring the variation in surface brightness of the lunar disk through the time period of the eclipse. We made use of the



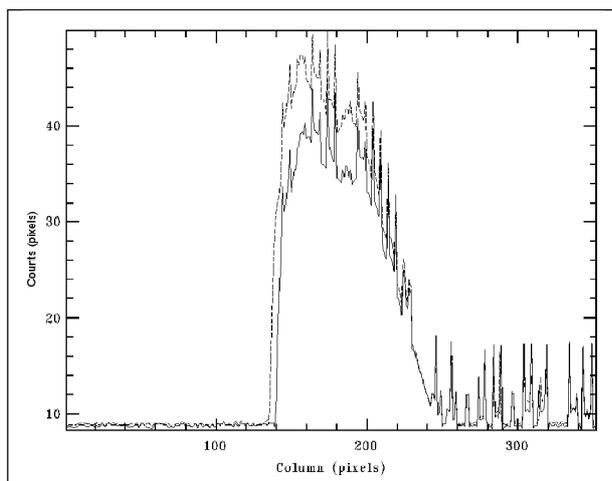
Figure 1. Surface brightness profile of Lunar disk.



software facility IRAF (Image Reduction and Analysis Facility) with Image Magic to convert jpeg images of lunar eclipse into fits format. Here we discuss the changes in the surface brightness profile of the Moon at the end of the umbral phase. *Figure 1* shows its surface brightness profile. We expect the width and height of the Gaussian function (as shown in *Figure 1*) to increase as the Moon reappears from the Earth's shadow.

Towards the end of the umbral phase, relative brightness and size of illuminated fraction of lunar disk changes at a much slower rate. By comparison and superposition of the graphs, as shown in *Figure 2*, we can recognize a point when the change in brightness

Figure 2. Change in surface brightness profile of the Moon in an interval of 1 minute.



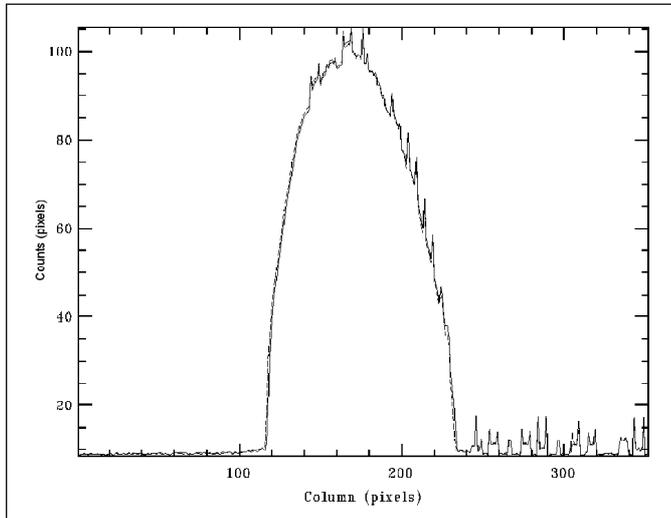


Figure 3. Change in surface brightness of lunar disk inside the Earth's penumbral shadow.

does not correspond to change in the profile width. This we identify as the boundary of penumbra and umbra (*Figure 3*).

The penumbra shadow moves over the disk of Moon and its brightness increases very slightly. This explains the constant width of Gaussian function and the slight increase in the brightness. Also one can observe a little shift of the Gaussian wave from right to left (*Figure 4*). This actually represents physical motion of the Moon within the frame of webcam capturing the event. This is one of the limitations of a telescope with no tracking facility.

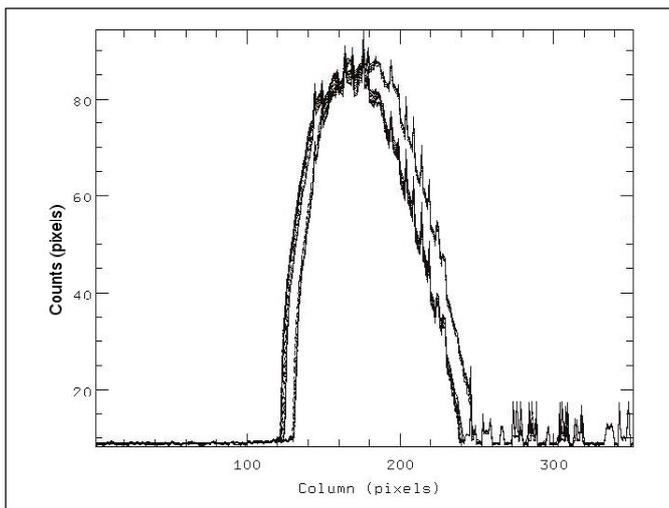
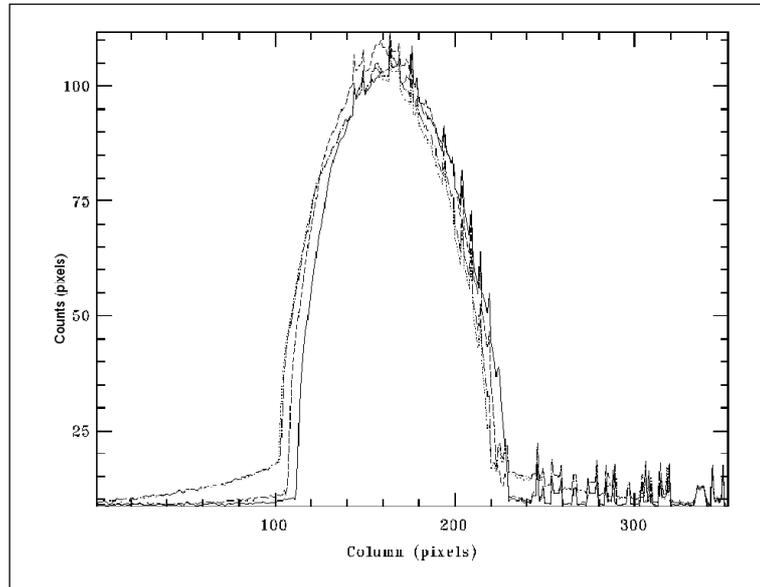


Figure 4. Superimposed graphs showing change in surface brightness of lunar disk over a period of 20 minutes.



Figure 5. Superimposed graphs over a period of 5 minutes showing the increase in the background count on the left edge of the graph.



In the last few brightness profiles one can see a little rise in the background count on the left of the Moon and hence towards its eastern edge (*Figure 5*). We have concluded that this is its eastern edge by noting the fact that the Moon's proper motion is towards the east. This raise in the background count in the eastern direction can be accounted for by noting that the end of the eclipse was very close to the time of the sunrise.

Acknowledgements

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- D Tody, IRAF in the Nineties in *Astronomical Data Analysis Software and Systems II*, A.S.P. Conference Ser., edited by R J Hanisch, R J V Brissenden and J Barnes, **Vol. 52**, p.173, 1993.
- N Rathnasree, Director, Nehru Planetarium for support and valuable guidance.
- Rajesh Harsh (artist) and other staff in saving data from webcast, Nehru Planetarium.

We can corroborate the results with yet another technique (contours of equal brightness) to show exactly how the shadow is moving on the lunar disk and how much area of the Moon is still eclipsed.

On observing the sequence of these contour plots (*Figure 6*) we can estimate the motion of Earth's umbra shadow over the disk of Moon with little effort.

Comparing the two images *Figures 6* and *7* of the eclipsed moon, not only the percentage of eclipsed moon can be estimated but also the direction and speed of umbra shadow over the Moon disk can be visualized easily.

Comparing *Figure 8* with the *Figures 6* and *7*, we can deduce how the two edges are moving towards each other; the end of the



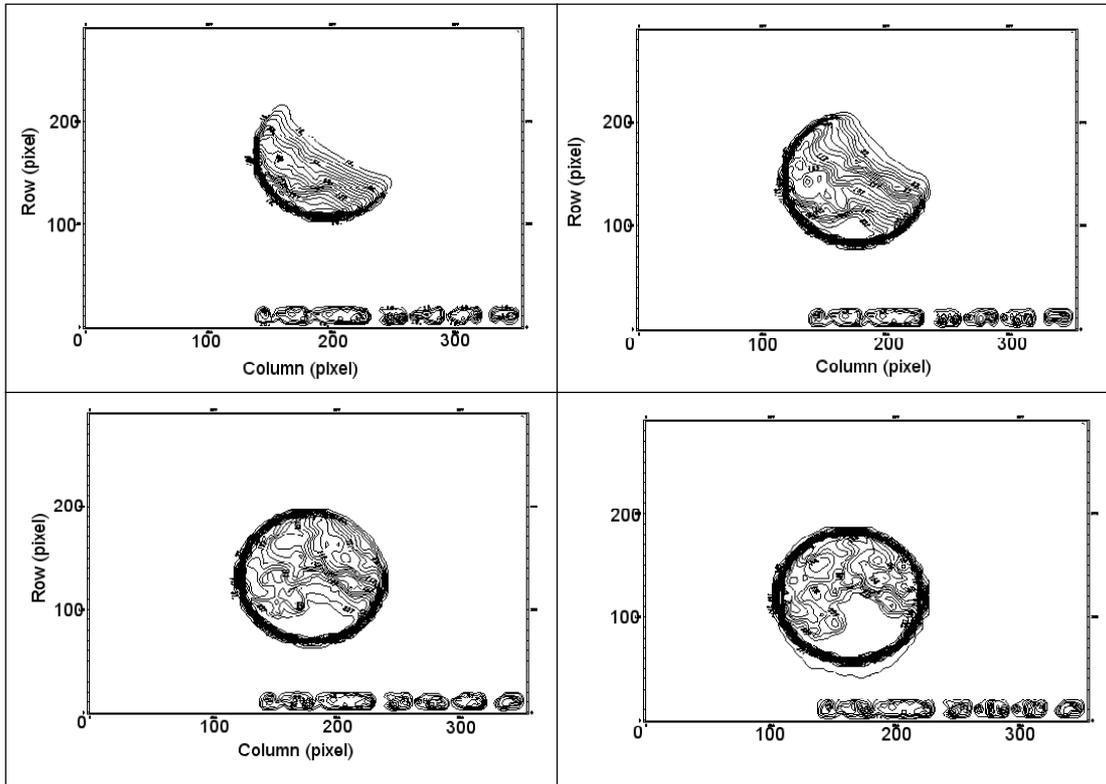


Figure 6 (top-left). Contours of equal brightness showing clearly almost half eclipsed Moon.
Figure 7 (top-right). Contours showing about 20% of Eclipsed Moon.
Figure 8 (bottom-left). Contour showing about 10% eclipsed Moon.
Figure 9 (bottom-right). Contour showing Moon inside the Earth's penumbral shadow.

umbral eclipse or the 4th contact can be estimated as a point when these two edges meet each other. We feel this is a better method of estimating the commencement of penumbral eclipse.

Conclusion

This article highlights the contribution of amateurs to the advancement of research in the field of astronomy.

Suggested Reading

- [1] Fits2jpeg – http://fits.gsfc.nasa.gov/fits_viewer.html
- [2] IRAF Facility – <http://iraf.noao.edu/>– 1 Surface brightness profile of Lunar Disk.

