Using a Web Cam CCD to do V Band Photometry

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Abstract

With the plethora of cheap web cam based CCD cameras in the market today, it seemed expedient to find out if they can be used to do photometry. An experiment was planned to determine if it was possible to do this kind of exacting measurement. Arne Henden (AAVSO) believed it would be possible to do V band photometry to 0.05 mag accuracy with a web cam CCD. Using a 6" refractor, the heart of M42 was repeatedly imaged. Theta 2 and SAO 132322 were the comparison stars and V361 Orion was the target variable. Since the ¼ HAD CCD chip only allows for a field of 10x7 arc minutes using the 6" refractor, the number targets was limited. The RGB on the chip itself provides the filters needed for photometry. The G band pass on the chip ranges from 425-650 nm with a peak band pass at 540, V band pass is 475-645 with a peak at 525. The results indicate that a web cam CCD can be used for V band photometry. With a 10 second calibrated exposure without the Peltier cooling being engaged, the results for the 2 target stars were ± 0.18 mag. The star Theta 2 was 0.18 brighter in V than the actual measurement from the Tycho catalog. SAO 132322 was -0.012 mag dimmer than the listed Tycho measurement. Then using SAO 132322 and Theta 2 as comparison stars, V361 Orion was estimated at 7.786 magnitudes. This is inline with visual estimates received before and after this date. With more estimates of known magnitude comparison stars, a correction factor should be estimated and applied to the variable work that will make it more accurate. This correction factor should bring it close to Arne Henden's estimate of 0.05 mag accuracy.

1. Introduction

A short visit with just about any amateur astronomy forum indicates the high level of interest in astronomical imaging. Though much of the imaging is done with DSLR cameras at this time there is still a number that are using web-cam based CCD systems. These systems are cheap and easily obtainable. Modifications can be made by the user or cameras purchased with the modifications already included. If these readily available cameras can be used for photometry then many amateurs can make real contributions to science.

The telescope for this effort was a Celestron 6" achromatic refractor mounted on a SkyView Pro Mounting. To help centering, a 1.25-inch flip mirror system mounted on a 2 inch adaptor was used. No focal reducers or filters were used. The SkyView Pro mounting uses a non-GOTO dual control tracking system. It would track without star distortion for 45 seconds with the camera setup.

For the test a SAC-7b camera was used. It features a Sony ¼-inch Progressive Scan HAD ICX098Ak chip. This is an anti-blooming color chip. There is a Peltier cooler installed though it was not used for this experiment since many amateurs have converted their own cameras and they do not have cooling features. The camera control software was Astrovideo 3.5.0 and the images were processed by AIP4Win V. 1.4.21.

This setup is an early example of low cost webcam CCD technology. The anti-blooming feature was good for pretty pictures but hurt the camera's linearity. The color chip also seems to be a disadvantage on first glance. Upon consultation with Arne Henden of the AAVSO it was suggested that the built in color filters could be used to provide acceptable V photometry to a 0.05 magnitude accuracy. This would be sufficient to provide low-level photometry that would still be much improved over visual observations. A whole new area for amateurs, with very low cost equipment, could dramatically expand the numbers participating in variable star research.

2. Characteristics

Upon examination it seemed that using the built in Green band pass filter to do V band photometry is possible and even practical. Below is a comparison of the traditional UVBRI filters and the spectral characteristics of the Sony HAD ¼-inch CCD chip.

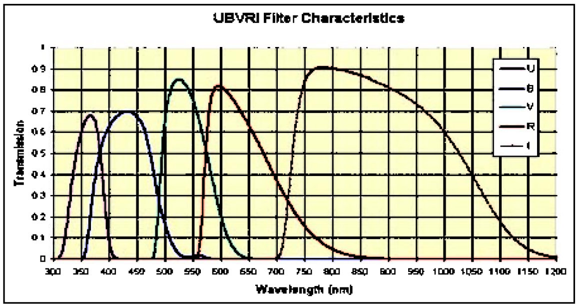

Figure 1. Filter characteristics for the UBVRcIc system.

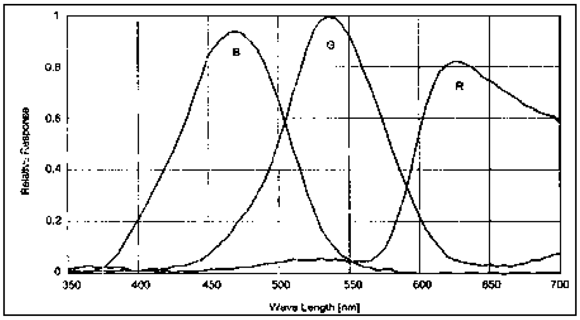

Figure 2. The spectral response of the built in RGB filters on the ¼" Sony HAD CCD.

As you can see the spectral response of the built in filters are very similar to the BVR of the UVBRI filter set. The G band on the chip, ranges from 425-650 nm with a peak band pass at 540 and the V band is 475-645nm with a peak at 525nm. The others are similar but not as close. B band is 350-555 nm with the peak at 425nm. The B of the UVBRI set is 365-550nm with a peak of 470 nm. The R band is 560-850nm with a peak at 625nm.

The conclusions are that you can use an RGB based webcam CCD chip to do serious photometry. Though the numbers seem to indicate that you can do photometry in BVR with this setup, only the V band was experimented with since it corresponds closest with visual observations.

3. The Procedure

Because of the small field of view of the Sony HAD 0.25-inch chip with an f/8 telescope, the targets were limited for this test. The trapezium area of M42 was chosen because of the proximity of several brighter comparison stars to variable V361 ORI (SAO 132329). This is an under-observed variable that is well within the range of an unguided webcam based CCD camera. Due to it's proximity near the Trapezium it is also an easy find for an amateur.

Several images of the Trapezium area were taken with exposures of 5 second, 10 seconds, 15 seconds and 20 seconds. With the 5 second exposure the image did not include the variable V361 ORI, the 10-second exposure captured the whole field of comparison stars as well as the variable in question and anything longer than 10 seconds overexposed the brighter comparison stars and caused them to become un-measurable. The final image used for the measurement was a 10-second image captured in FITS format. The image was automatically broken down into RGB channels by the Astrovideo program. Only the G channel was used for measurement.

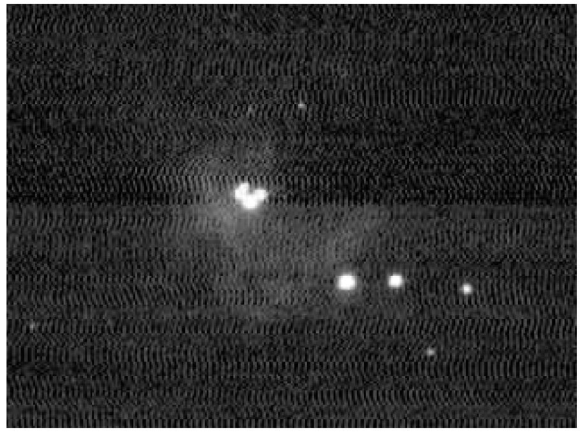

Figure 3. The Trapezium, Theta 2 and V361 ORI from a C6" Refractor and SAC-7b camera with a calibrated 10 second exposure. Unguided.

The frame was calibrated by using a dark frame consisting of 20 dark frames taken at 10 seconds and combined. There is still a great deal of signal noise due to the lack of cooling on the chip. Though it is better with the cooling activated, it still shows a lot of image noise. There was no combining of images; only one-10 second frame was used to measure magnitudes. The calibration and measuring was done in AIP4WIN using standard dark subtract and comparison star photometry.

4. The Data

The comparison stars for this estimate were Theta 2 and SAO 132322. The star Theta 2 was .18 brighter in V than the actual measurement from the AAVSO VSP. SAO 132322 was -0.012 mag dimmer than the listed Tycho measurement. Comparison stars SAO 131887 at 6.2 magnitudes (AAVSO) and SAO 131876 at 8.0 (Tycho) were used to check Theta 2 and SAO 132322. These stars were chosen because they would be linear due to their lower magnitude. A check was performed since the chips anti-blooming properties could change the reading of Theta 2 if it went into effect. Then, using SAO 132322 and Theta 2 as comparison stars, V361 Orion was estimated at 7.786 magnitudes. AIP4WIN comparison photometry tools were used. This is inline with visual estimates received before and after this date.

5. Conclusions

It is possible to use a webcam CCD to do V band photometry. If other standard stars are imaged and magnitudes compared, then a correction factor can be applied to the observations and more precision achieved. Air mass corrections would also bring it closer to the target of 0.05 magnitude accuracy.

One very important factor is to not overexpose the images. Since there is anti blooming on most chips of this kind you must stay below the saturation threshold for a star. The images will stay linear if care is used in the exposure time.

Though it is quite possible to achieve good results, it is not easy. Dedicated astronomical CCD's make doing precise photometry much easier. There are features like auto dark subtract that speed up and simplify the process. Though the costs are higher, it will make photometry more enjoyable. Still, for the amateur just wanting to experiment with photometry, a webcam based CCD will provide many hours of satisfying science.

6. Acknowledgements

Thanks to Arne Henden for the original idea, along with the entire AAVSO organization. Rik Hill's comments and help have also been invaluable as well as those from Tom Krajci.

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