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A variable star and light pollution monitor for Armagh Observatory

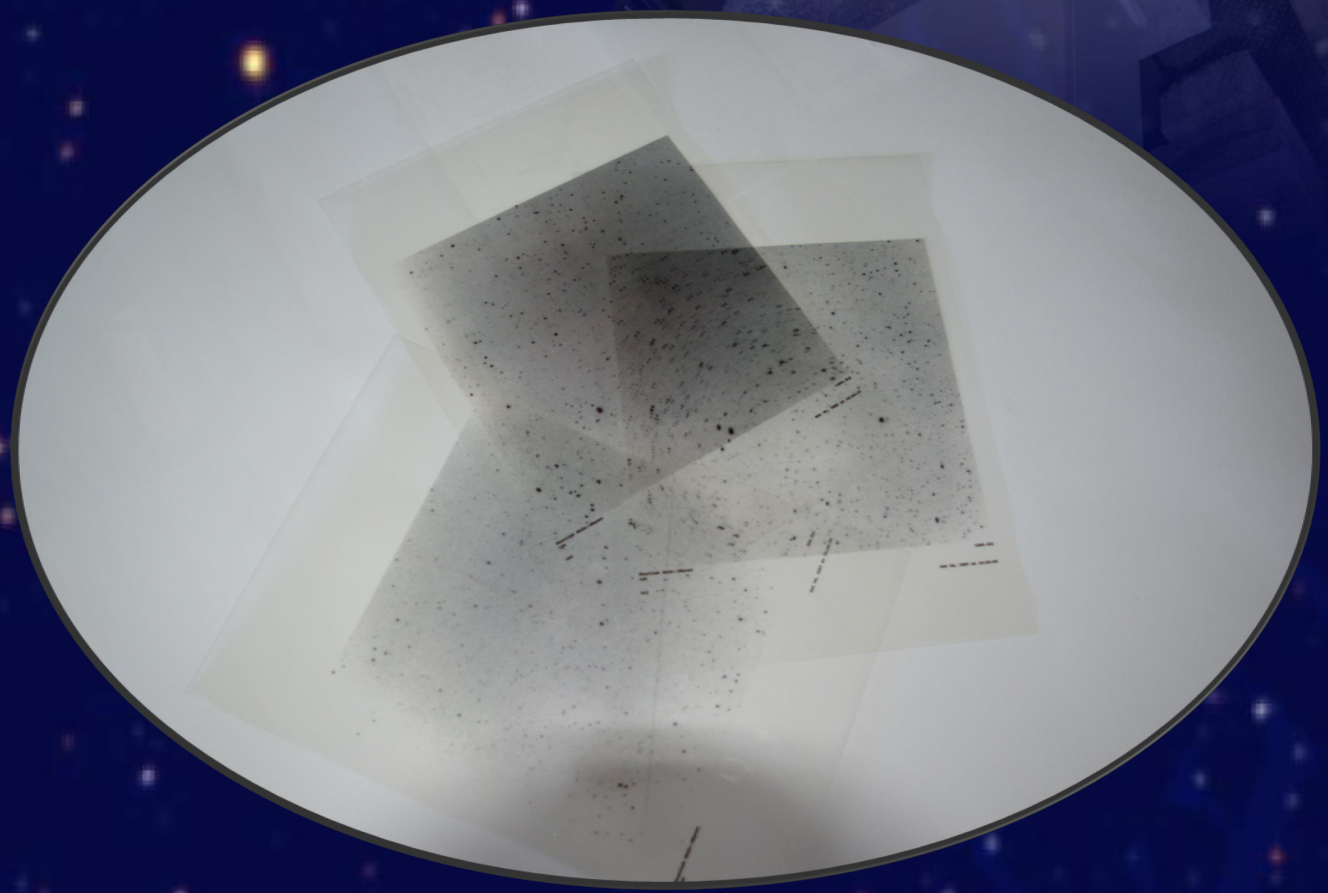
What is a variable star?
A variable star is a star that shows large variations in brightness over time-scales that can vary from a few minutes to a few years. This can be caused by intrinsic variability (pulsations) and extrinsic variability (eclipsing).

What is light pollution?
Light pollution is excess or obstructive light caused by humans. It has a great number of effects, but the one we are most concerned with here is the great astronomical effect. Its source is objects light offices, sporting events, advertising and exterior lighting. This glow causes difficulty in detecting fainter objects in contrast with the sky itself. There are a few ways to reduce this effect, such as filters, though not cut it out completely.

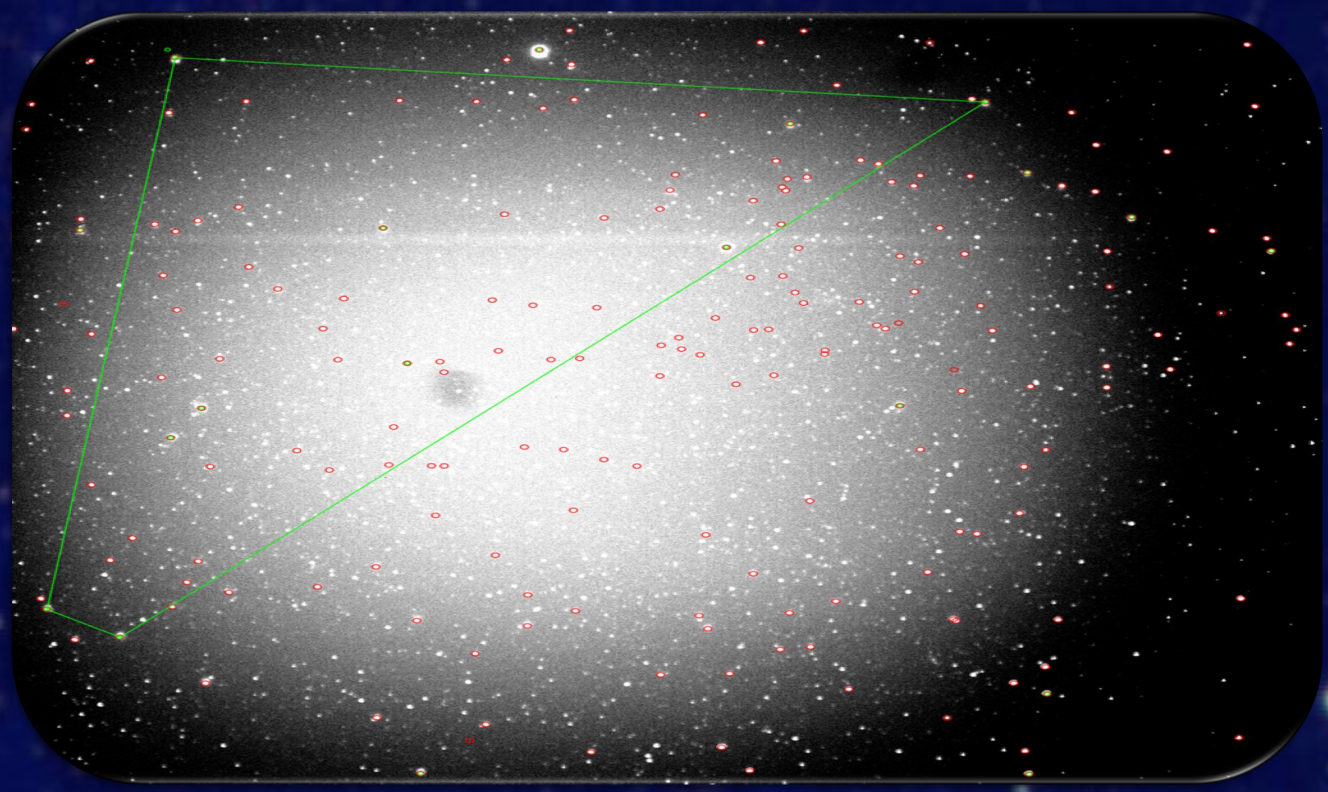
What is magnitude?
Magnitude is a measure of brightness, particularly used with stars. There are two kinds of magnitudes for stars. One kind is apparent magnitude. The other is absolute magnitude. Apparent magnitude is how bright the star appears to us on earth. Absolute magnitude is the stars actual magnitude. There is a difference in the two as a dim star which is nearby looks bright and a bright star that is far away looks dim. In the 2nd century B.C the Greek astronomer Hipparchus described the brightest being first magnitude, next brightness being second magnitude and so on. In the mid 1800s, astronomers determined mathematically what Hipparchus did visually. This was by giving his scale a definable basis. They worked out that first magnitude was on average 100 times brighter than the 6th magnitude star. Once further measurements were done they showed that for every increase in one order magnitude there was an increase of 2.51 fold in brightness. This formed an equation of apparent magnitude Mv which is:

Mv = -2.5 log f + constant
were f is the flux of that star
f = (counts/ exposure)

The images that we worked on were taken by the Polar Bear Telescope. This telescope comprises of a set of three wide angled telescopes which are located on fixed mounts on the observatory roof. They are aimed at a radius of ten degrees centred on the north celestial pole, so they overlap in every frame.



Astrometry.net
This is the first program which I used in order to process the images. This software distinguishes the stars inside the image and then constructs an equation, in order to fix bearings, which describes the transformation between image co-ordinates to sky co-ordinates. It will mark out the stars which it recognises, then construct a shape that it will use to work out the position of the rest of the stars, in Right Ascension and Declination. By doing so it also produces a image, which is shown on the top right.



SExtractor 2.5.0
This is primarily used to measure the flux (the total number of photons in a given interval) recorded by the detector. During its first pass of the image it constructs a model of the sky background, and estimates some global statistics. During the second pass of the image the background is subjected and filtered.

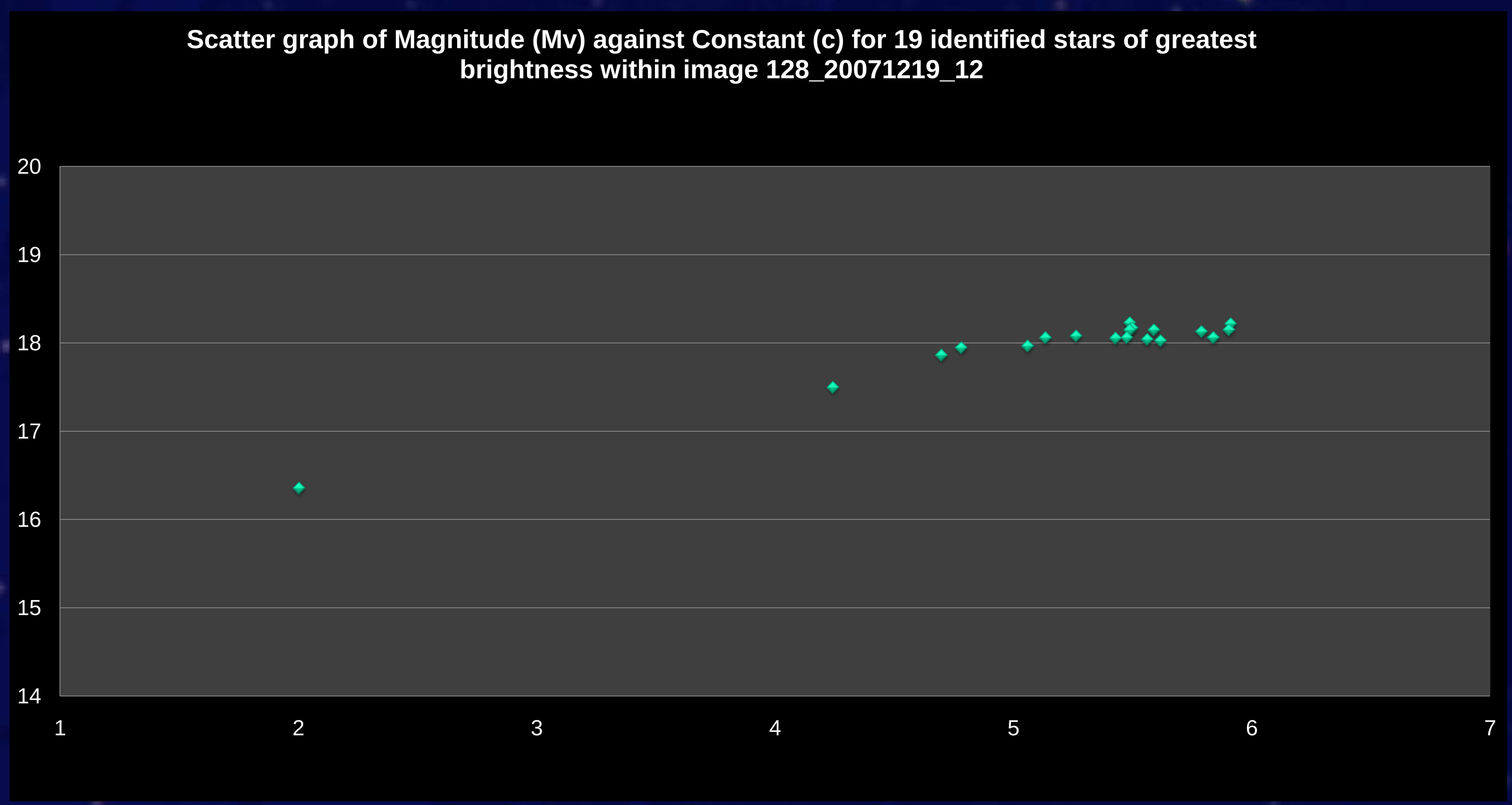
Shell Script
This was used to allow the two applications to run consecutively, with Astrometry.net running first. It would also place all the gained information into a file by the extension .phot.

I then constructed a spreadsheet in order to process these results. The first spreadsheet was based on the 19 brightest stars, from the information contained within the .phot file. This was in order to work out the constant C. With this we were able to receive the stars Identifier and magnitude from the SIMBAD Astronomical Database.

Now to work out the instrumental magnitude of these stars I used the equation:
Mv = -2.5 * (counts / exposure time) + C
Instead to work out the instrumental magnitude I used:
Minst = -2.5 (counts / exposure time)
Also the error in Minst = -2.5 log (counts / error)

Now using this information I worked out the constant C for the 19 brightest stars. To do this a subtracted the instrumental magnitude from the official magnitude which I had received from the SIMBAD Astronomical Database.

I then constructed the following graph of Mv against constant C:



As you can see in the graph the 7 first results are inaccurate and out of correlation. For this reason we may leave out them out. They are inaccurate as they were so bright they saturated the pixels. Now we worked out an average of these 19 stars for the constant C, excluding the 7 brightest.

We can now use this constant C for the rest of the objects within the image. This allows us to work out the calibrated magnitude of every object on that image. This is necessary to have if one is aiming to observe the variation in a star over a period of time. However if one wants to be able to pick this star out of all the data within .phot file then there needs to be a way to automate this. So to process this data I began a to create a software tool in C++ that would allow us to process this data and also work out more things within the data and use it for other output.
This program will be further developed for a number of functions. One of these being that it will be combined with standard stars, which will be used to identify the area of stars and to also help identify other stars within the image. Also to keep track and locate one particular star if you are measuring its variability over a period of time. This will hopefully aid the observatory in monitoring the variability of stars but also to allow them to identify new stars that were previously not known and add them to a catalogue of known stars.