

## Image Processing in Introductory Survey Courses in Astronomy and Meteorology

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Image processing contains a useful set of tools for studying both astronomy and meteorology; hence, their use should be a part of any survey course in these academic disciplines. The author has attempted to provide some insight into the use of the image processing through both laboratory exercises and the lecture.

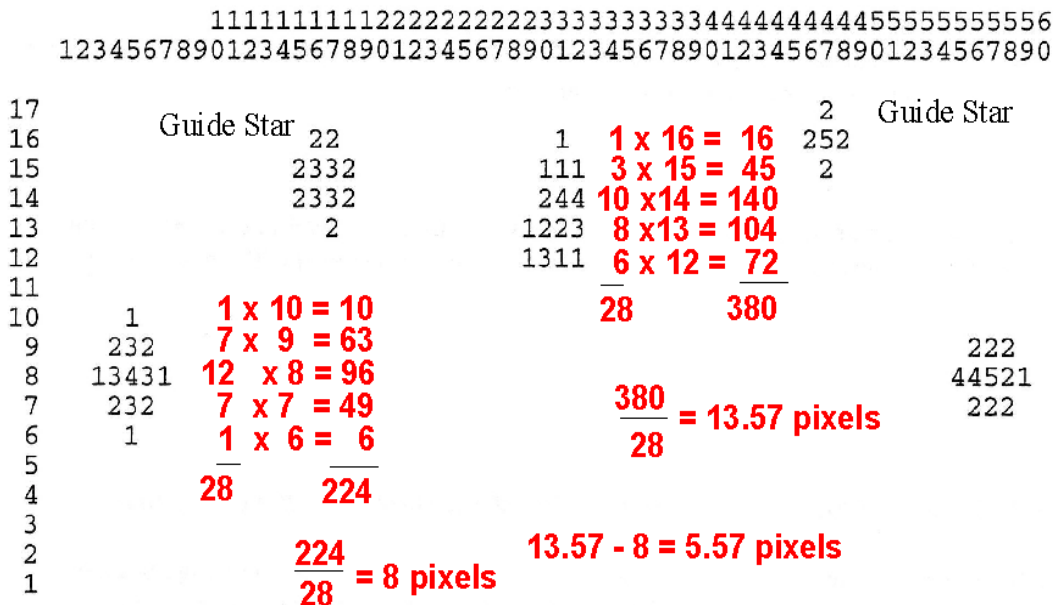
In the lecture I describe how the Charged Coupled Device works in both astronomy and meteorology. The description includes the rows and columns of photo diodes which are interrogated by the electronics to provide both images and matrix data sets.

The astronomy laboratory manual by Robinson and Wright (1993, 1996) provides for

four image laboratories, two in image processing and two in image interpretation. The first of the two image processing laboratories defines the term pixel and does some simple pre-processing and pixel by pixel color substitution as well as some edge enhancement. In the second, *Determining the Distance to Barnard's Star using Parallax*, the students calculate the positions of images of stars in a data matrix, convert the pixel distances to arc seconds, and then use the parallax angle P in the formula  $D = 1 / P$  to calculate the distance to Barnard's star.

Figure 1 shows the image as given in the laboratory manual. Motion across the figure is proper motion while motions in the vertical are

Figure 6 is a composite of three images of Barnard's Star and the two guide stars. The image on the lower left was the first; the second, in the middle, was taken six months later. The third, on the lower right was taken a year after the first.



**Figure 6** - Composite of the three positions of Barnard's Star made by adding the three images and adjusting the values of the guide stars to their original values.

Figure 1 Data Array From the Laboratory Manual With Sample Calculations in Red (Arial Type)  
 One pixel = 0.2 arc seconds

parallactic motions. The three positions of Barnard's star are the lower three while the upper two, one centered on column 17 and the other on column 47 are "fixed stars" to orient the data.

The laboratory exercise which has been carefully constructed to produce a value within 5% of the book value, is in two parts. The first part the students estimate the locations in terms of row and column numbers of the positions of the star images taken at January, June and January of the next year. The difference in row number gives the parallactic motion and the students must convert to arcseconds and calculate the distance.

In the second portion, the student is asked to make a better determination based on weighted averages of the positions. The numbers in red in figure 1 show the calculations which are done to determine the weighted average positions for the parallactic motion over the year. The students then convert these positions in pixels to arcseconds assuming the distance between pixels is 0.2 seconds of arc. The parallax angle is defined as one half of the angular distance and the students can then determine the distance to Barnard's star within a few percent.

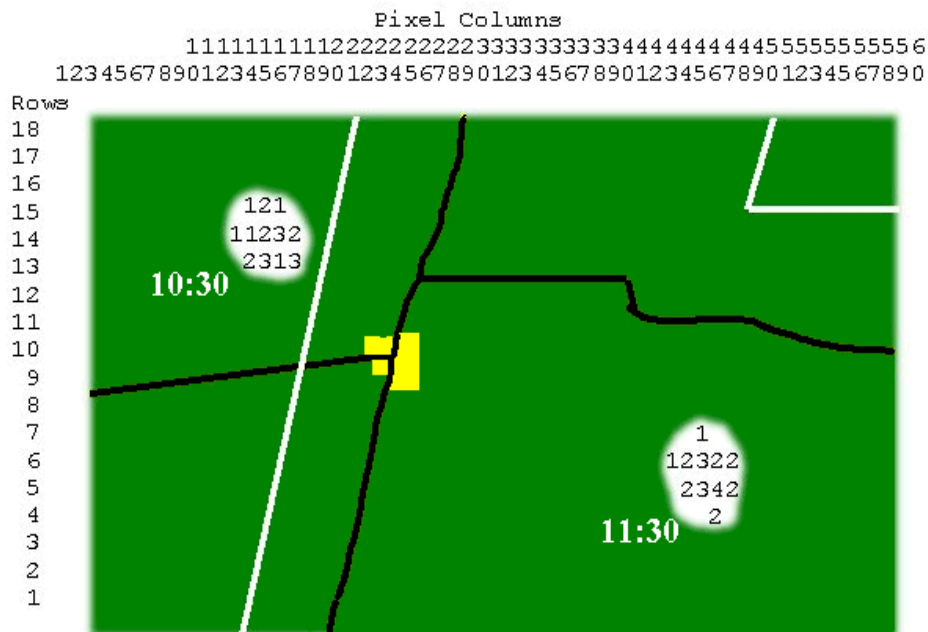
A similar lab which determines the motion of clouds in the wind can be done in the introductory survey in meteorology. The laboratory

exercise uses a simulated satellite image data on a base map such as in Figure 2 to show the movement of a cloud over a one hour period. Depending on the level, the student can use the approximate positions of the cloud as shown by infrared values at the two time periods or use the weighted average to determine the locations in terms of pixels rows and columns. Once the differences in positions in terms of rows and of columns are determined, the differences should be converted to miles or kilometers.

The student can then use the Pythagorean Theorem to yield the distance of movement. The speed and direction of the cloud can be determined. Note that the cloud movement may differ from the wind speed.

Since clouds rarely are constant even over as short a period of time as an hour, the changes can be seen. Assuming the numbers are infrared values and these relate to temperature of the cloud with 1 being the highest temperature and 9 being the coldest, the students can make a judgement as to the growing or decaying nature of the cloud.

Reference: Robinson, H. W. and G. Wright (1963, 1966): *Laboratory Manual in Astronomy*, Montgomery College Press, Rockville, MD



**Distance between pixels is 1/2 mile. 1 pixel = 0.5 miles**

Figure 2 IR Data Plotted on a Map Background for Determining Cloud Motions