Astronomical Observing Techniques 2018: Exercise on Signal and Noise (Due on 5 March 2018 at 11:00)

February 26, 2018

101.6	110.9	105.7	116.9	94.7	104.8
106.7	93.9	103.4	94.5	89.1	88.2
110.8	111	113.3	94.2	85.2	101.7
117.3	100.8	113.1	130.2	106.5	101.2
108.1	105.7	94.6	90.1	106.2	105.7
101.6	95.3	99.9	83.1	70.7	100.6

Consider a perfect (i.e., no detector noise) but small, 6x6 pixel detector array, which is exposed to a uniform sky background that will produce a constant flux level plus the associated photon shot noise. In addition to the sky background we are observing a very faint star. For simplicity, we assume that

- the flux from the star will be uniformly spread across four pixels
- the star will illuminate the central four pixels of the array
- the signal from the star has no associated photon (shot) noise.

The measured pixel values of the array are given in the figure shown above.

a) Calculate the mean and the standard deviation of the pixel values of the array. Since we know that the central four pixels contain the source we exclude them from the statistics. What is the relative noise (1σ/mean) in percent?

b) Now we consider if we can claim a detection of a source on a pixel-by-pixel basis. We know that the four central pixels see the source flux. What are the significances of detection (in standard deviations) for each of the four pixels?

c) In order to improve the S/N we now re-bin the 6x6 onto a 3x3 array. In other words, we combine (coadd) the values from 2x2 neighboring pixels. What are the pixel values now? Draw a 3x3 table.

d) Calculate the mean and the standard deviation of the re-binned array. Again, exclude the central pixel, which contains the source, from the statistics. What is the relative noise in percent? How does it compare with the previous "single pixel" S/N?

e) What is the significance of detection of the star in the central pixel? Is the level of confidence high enough to claim a reliable detection?