Test report comparing HCSS and IDL (astrolib) implementations of the DAOPHOT source extraction algorithm

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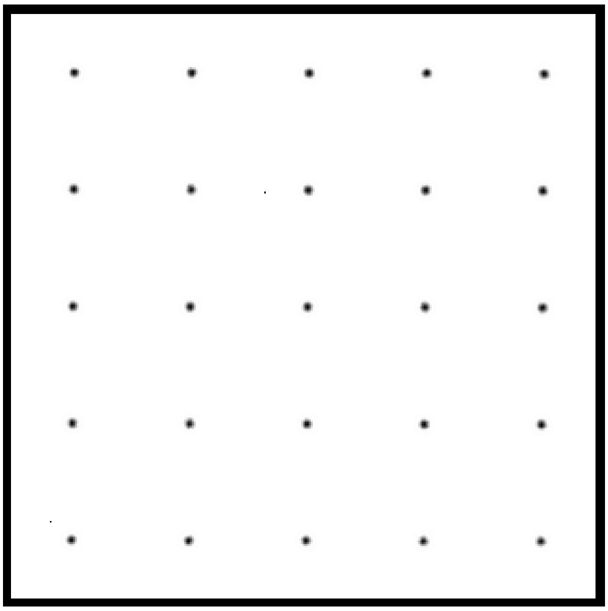

Figure 1: Sample image used for the source extraction tests. The image was created using a grid of sources with an Airy profile of size appropriate to 250 micron observations with SPIRE, which was then run through the SPIRE Photometer Simulator and processed using the HCSS pipeline. The image has 6 arcsec pixels, two of which have NaN values (shown as dots in the image).

1 Introduction

The HCSS source extraction module (hereafter SXT) contains an implementation of the "classic" DAOPHOT source extraction algorithm [AD01]. DAOPHOT is also implemented in The IDL Astronomy User's Library,[1] notably in the FIND and APER procedures.

It should be noted that there have been various incarnations of the DAOPHOT algorithm, but both SXT and FIND are close to the "classic" (1987) version of DAOPHOT.

1.1 Applicable Documents

AD01 DAOPHOT - A computer program for crowded-field stellar photometry, Stetson (1987), PASP, 99:191)

1.2 Builds and images used for the tests

SXT was tested using HCSS DP-SPIRE continuous integration build 1.2.548 RC1. FIND, from the July 2009 release of The IDL Astronomy User's Library, was tested using IDL 7.0.6.

The test image is a 250 micron simulated image of a grid of sources, shown in Figure 1.

2 Results using SXT

The image was imported into HIPE and the sourceExtractor task was executed, with detThreshold = 2, FWHM = 18.6, algorithm = "daophot" and pixelRegion = 2.5. At this threshold, the

[1] `http://idlastro.gsfc.nasa.gov/`

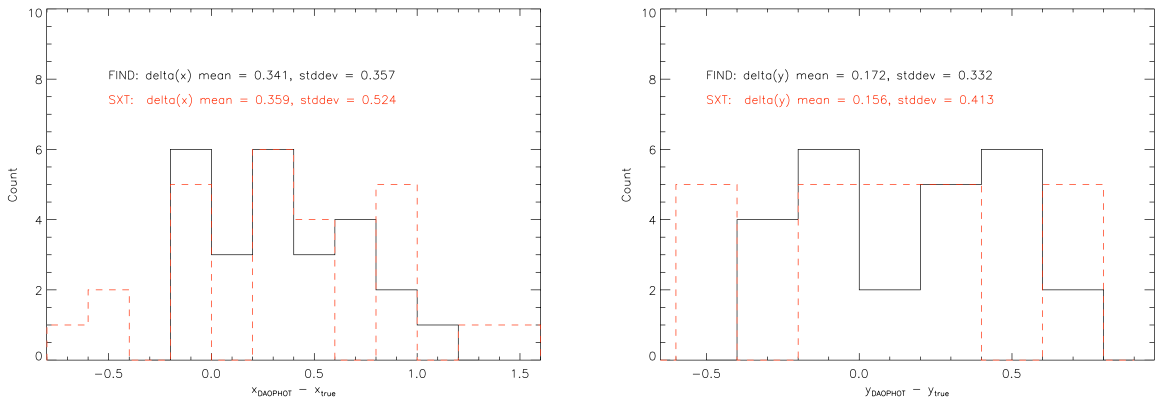

Figure 2: Comparison of the X pixel position (left panel) and the Y pixel position (right panel) between the two methods and the input (true) source positions. The solid (black) histogram is for FIND while the dotted (red) histogram is for SXT.

25 sources in the image were recovered. A comparison of the fluxes and positions with the input fluxes and positions and with the IDL fluxes and positions will follow below.

The positions of these sources are all given at the centre of a pixel.

It was found that, for detThreshold of 0.6 or higher, 25 sources were recovered, but the number of sources increased for lower values of the threshold, reaching a maximum number of detected sources of 1214 for threshold detThreshold ≤ 0.04. For high values of the threshold, 25 sources were recovered with detThreshold as high as 150, after which the number of sources recovered decreased such that a detThreshold of 300 recovered no sources.

3 Results using FIND

The image was imported into IDL and FIND was executed with a threshold of 0.02 and using the default values for the low and high cut-offs for the image sharpness statistic (0.2 and 1.0) and for the image roundness statistic (-1.0 and 1.0). (These limits are the same as those used in SXT, as the log messages make clear.) No low and high bad pixel values were set, which is also the default. 25 sources were found in the image.

Varying the detection threshold, it was found that 25 sources were detected for threshold between 0.002 and 0.05. For values lower than 0.002, the number of sources increased, reaching a maximum of 5246 sources for threshold $\leq 8 \times 10^{-7}$. For a threshold of 0.1 or higher, no sources were found.

At this point, APER was executed to find the aperture magnitudes. Parameters for this were chosen to match the extraction in HIPE. These values are not provided for the user in HIPE, but were obtained through editing the Java source code. These parameters were as follows: the FWHM in pixels for the photometry aperture radius (i.e., $(18.6\,\mathrm{arcsec})/(6\,\mathrm{arcsec\,pixel}^{-1}) = 3.1\,\mathrm{pixel}$) and 3.875 and 9.3 pixels respectively for the inner and outer radii to be used for the sky annulus (i.e., 1.25 and 3.0 times the FWHM).

4 Comparison

Figure 2 shows a comparison between the extracted X and Y (pixel) positions and the positions of the sources in the input catalogue. it can be seen that both methods product comparable

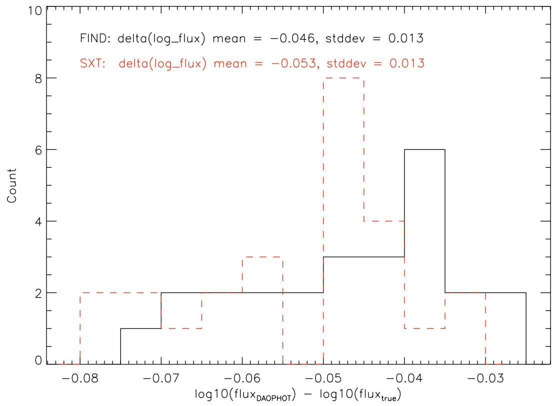

Figure 3: Comparison of the flux estimate of the two methods with the fluxes of the input (true) sources. The solid (black) histogram is for FIND while the dotted (red) histogram is for SXT.

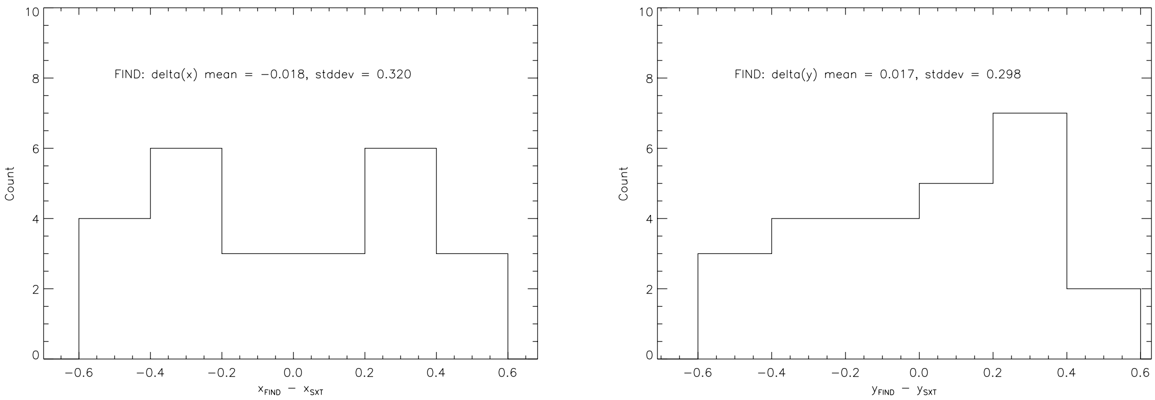

Figure 4: Comparison of the X (left panel) and Y (right panel) pixel positions between FIND and SXT.

results, with a systematic offset of approximately a third of a pixel, and with a similarly-sized scatter. The systematic offset, which is common to both FIND and SXT, may be an effect of the Spire Photometer Simulator.

Figure 3 gives a comparison of the extracted fluxes, when compared with the fluxes of the input sources. Once again, the quality of the fluxes of FIND and SXT are comparable.

Figure 4 shows a comparison between the extracted X and Y (pixel) positions between FIND and SXT. In this case, the systematic offset is removed, but the scatter remains similar to Figure 2. The likely cause of this scatter is that SXT source positions are in the centres of pixels.

Figure 5 gives a comparison of the extracted fluxes between the two methods. It can be seen that the two methods produce very similar results.

5 Conclusions

From these tests it is clear that the HCSS implementation of DAOPHOT produces very similar results to the IDL implementation. However, the following points should be noted.

- HCSS source positions have the limitation that they are all in pixel centres. A method should be implemented to give more precise positions; without this, the source positions

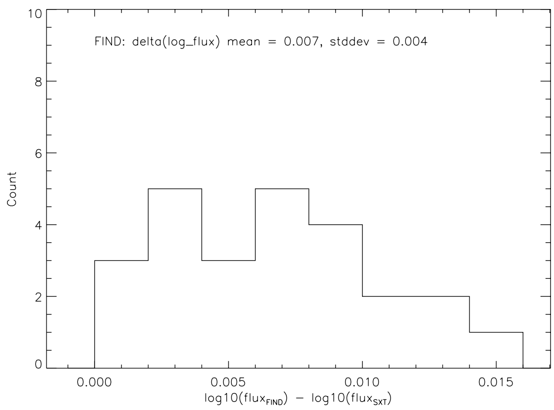

Figure 5: Comparison of the flux estimates between FIND and SXT.

can be accurate only to the nearest pixel [SCR HCSS-7564].

- The thresholding between FIND and SXT is very inconsistent, and evidently the detection threshold has a different meaning. However, the end user will want to specify a threshold in sigma, not in some DAOPHOT units, and this is a major omission in the HCSS DAOPHOT implementation. (The IDL software contains routines that make it possible to give a threshold in sigma.) Further tests could have been performed on more realistic images, to see how many sources FIND and SXT find for different detection thresholds, but this would not be a useful exercise with the current inconsistency in the thresholds [SPR HCSS-7565].
- Both FIND and SXT use some kind of aperture photometry to estimate the final fluxes. It is questionable whether this is the best way for fluxes to be estimated. This needs further investigation. However, as currently implemented, the HCSS DAOPHOT is consistent with the IDL DAOPHOT.