reconstruction (also known as *drizzle*), can be thought of as shifting and adding with a variable pixel size. For poorly sampled data, the shifted pixels retain the initial pixel size—the final image combines the shifts correctly, but the gain in resolution is minimal. For a well-sampled field, such as that of the Hubble Deep Field, the size of the shifted pixels can be made quite small, and the image combination becomes equivalent to interlacing. Drizzling also corrects for the effects of the geometric distortion of WFPC2; correction of geometric distortion is important if shifts between dithered images are of order ten pixels or more.

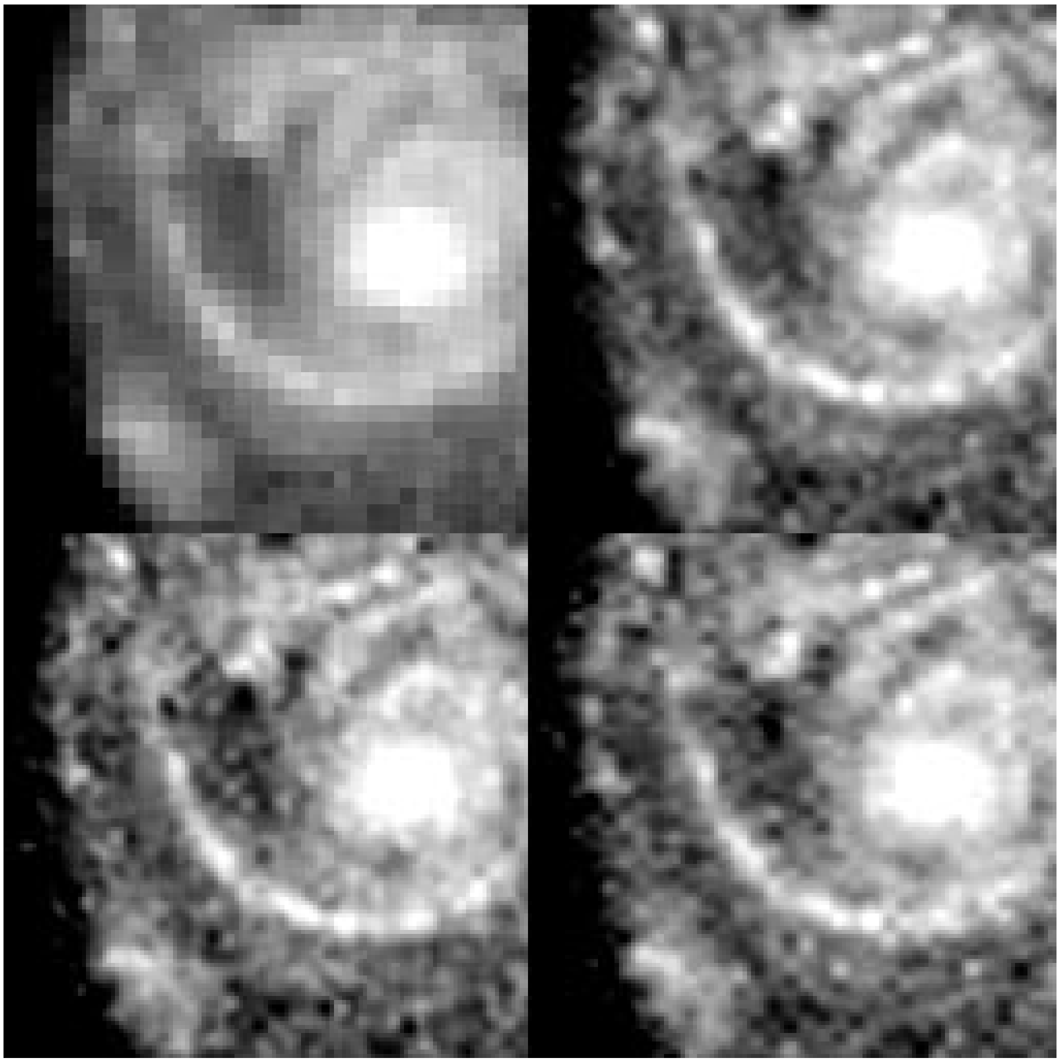
The drizzle algorithm was implemented as the STSDAS task **drizzle**, as part of the **dither** package, which helps users combine dithered images. The **dither** package is included in STSDAS release v2.0.1 and later, and includes the following tasks:

- **precor**: Determines regions of the image containing astrophysical objects and nulls the remainder of the image, substantially reducing the effect of cosmic rays and chip defects on the offset measurement. The ouput from **precor** is only used for offset determination and not final image creation.
- **offset**: Cross-correlates all four images in a WFPC image, creating output cross-correlation images with names that can be appropriately grouped by later tasks. Uses the task **crossdriz** to perform the cross-correlation.
- **crossdriz**: Cross-correlates two images, after preprocessing which includes trimming, and, if requested, drizzling to remove geometric distortion or rotation. **crossdriz** will also perform a loop over a range of test rotation angles.
- **shiftfind**: Locates the peak in a cross-correlation image and fits for sub-pixel shift information. The search region and details of the fitting can be adjusted by the user.
- **rotfind**: Fits for the rotation angle between two images. **rotfind** is called when **crossdriz** has been used to loop over a range of test rotation angles between two images.
- **avshift**: Determines the shifts between two WFPC2 images by averaging the results obtained on each of the groups after adjusting for the rotation angles between the four groups. **avshift** can also be used to estimate the rotation angle between two different WFPC2 images, when the rotation angle is a small fraction of a degree.
- **blot**: Maps a drizzled image back onto an input image. This is an essential part of the tasks we are developing for removing cosmic rays from singly-dithered images.

Additional information on these tasks is available in Fruchter et al. (1997) and Mutchler and Fruchter (1997), as well as the on-line help files.

Although reconstruction largely removes the effects of sampling on the image, it does not restore the information lost to the smearing of the PSF and PRF. Deconvolution of the images, however, does hold out the possibility of recapturing much of this information. Figure 28.3, supplied by Richard Hook of the ST-ECF, shows the result of applying the Richardson-Lucy deconvolution scheme to HST data, used extensively in the analysis of WF/PC-1 data. The upper-left image shows one of four input images. The upper-right image shows a deconvolution of all of the data, and the lower two images show deconvolutions of independent subsets of the data. A dramatic gain in resolution is evident.

Figure 28.3: Richardson-Lucy Deconvolution of HST Data



A version of the Richardson-Lucy (RL) deconvolution scheme capable of handling dithered WFPC2 data is already available to STSDAS users. It is the task **acoadd** in the package **stsdas.contrib**. In order to use **acoadd**, users will need to supply the program both with a PSF (which in practice should be the convolution of the PRF with the optical PSF) and with the offsets in position between the various images. The position offset between the two images can be obtained using the task **crossdriz** in the **dither** package.

In principle, image deconvolution requires an accurate knowledge of both the instrument PSF and PRF. At present, our best models of the WFPC2 PSF come from the publicly available TinyTim software (Krist, 1995). The quality of the TinyTim model can be improved substantially by taking into account the exact position of the source within the pixel. Remy et al. (1997) discuss how this can be accomplished by generating multiple TinyTim images at various focus and jitter values, oversampled with respect to the camera pixels. At present, this is very labor-intensive, and the results cannot be easily integrated into the existing deconvolution software. Another limitation of the existing software is that it cannot incorporate the significant variation of the PSF across the field of view. As a result, the Richardson-Lucy approach can only be applied to limited regions of a chip at a time. Nonetheless, tests done on WFPC2 images suggest that RL deconvolution can give the WFPC2 user a substantial gain in resolution even in the presence of typical PSF and PRF errors. Users interested in more information on dithering, reconstruction, and deconvolution should consult the February and September 1995 issues of the ST-ECF Newsletter, where these issues are discussed in detail.

28.6 Accuracy of WFPC2 Results

Table 28.6 summarizes the accuracy to be expected from WFPC2 observations in several areas. The numbers in the table should be used with care, and only after reading the relevant sections of this handbook and the documents referenced therein; they are presented in tabular form here for easy reference.

Table 28.6: Accuracy Expected in WFPC2 Observations

Procedure	Estimated Accuracy	Notes
Calibration (flatfielding, bias subtraction, dark correction)		
Bias subtraction	0.1 DN rms	Unless bias jump is present
Dark subtraction	0.1 DN/hr rms	Error larger for warm pixels; absolute error uncertain because of dark glow
Flatfielding	<1% rms large scale	Visible, near UV
	0.3% rms small scale	
	~10%	F160BW; uncertain
Relative photometry		
Residuals in CTE correction	< 1% rms (above 1000 DN)	
	3% rms (at 100 DN)	
Long vs. short anomaly (uncorrected)	< 1% rms (above 10000 DN)	
	5% (at 1000 DN)	
	15% (at 100 DN)	
Aperture correction	4% rms focus dependence (1 pixel aperture)	Can (should) be determined from data
	<1% focus dependence (> 5 pixel)	
	1-2% field dependence (1 pixel aperture)	
Contamination correction	3% rms max (28 days after decon) (F160BW)	
	1% rms max (28 days after decon) (filters bluer than F555W)	
Background determination	0.1 DN/pixel (background > 10 DN/pixel)	May be difficult to exceed, regardless of image S/N
Pixel centering	< 1%	
Absolute photometry		
Sensitivity	< 2% rms for standard photometric filters	Red leaks are uncertain by ~10%
	2% rms for broad and intermediate filters in visible	
	< 5% rms for narrow-band filters in visible	
	2-8% rms for UV filters	
Astrometry		
Relative	0.005" rms (after geometric correction)	Same chip
	0.1" (estimated)	Across chips
Absolute	1" rms (estimated)	

28.7 References

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