Quick Start Guide to DrizzlePac

Text in blue provides links to further documentation

Documentation

- DrizzlePac Website
- DrizzlePac Handbook
- Software Installation Guide
- Video Tutorials
- Examples
- Need Assistance?
    - DrizzlePac Forum
    - STScI Help Desk (help@stsci.edu)

Getting started

Download software

Define path to reference files

```
% setenv myref /path_to_reference_files/                        #from terminal
--> set myref = '/path_to_reference_files/'                      #from pyraf session
>>> import os;os.environ['myref']='/path_to_reference_files/'    #from python
```

Import software and check version information from pyraf

```
--> import drizzlepac
--> drizzlepac.__version__
--> from drizzlepac import tweakreg
--> from drizzlepac import astrodrizzle
```

Using the TEAL/EPAR GUI from within python

```
ipython
>>> from stsci.tools import teal
>>> import drizzlepac
>>> a = teal.teal('astrodrizzle')   # runs AstroDrizzle using TEAL/EPAR GUI
```

Initializing the WCS

Update the WCS keywords using the distortion reference files in the image header, eg. whenever using a new version of DrizzlePac

```
--> from stwcs import updatewcs
--> updatewcs.updatewcs('*flt.fits')
```

Special cases: Update the image header to point to an alternate set of distortion solutions, eg. the latest ACS time-dependent solutions

```
--> from astropy.io import fits
--> fits.setval('image_flt.fits', 'IDCTAB', value='/path/file_idc.fits')
--> fits.setval('image_flt.fits', 'NPOLFILE', value='/path/file_npl.fits')
--> fits.setval('image_flt.fits', 'D2IMFILE', value='/path/file_d2i.fits')
--> from stwcs import updatewcs
--> updatewcs.updatewcs('image_flt.fits')
```

** Distortion reference files for WFC3 and ACS = IDCTAB, NPOLFILE, & D2IMFILE and for WFPC2 = IDCTAB & OFFTAB.

TweakReg in a Nutshell

TweakReg is a tool to improve the image alignment using matched sources between images. The built-in 'imagefind' source finding algorithm is based on 'daofind' and works best for point sources. Externally-produced catalogs such as SExtractor may also be used as input, especially for extended objects. The accuracy of the results from any catalog depends on the quality of the measurements in those catalogs.

Parameters that control the WCS:

- 'update_hdr' - applies the tweaked fit to the image header. Set to 'False' until astrometric residuals and vector plots have been inspected.

To start, leave all TweakReg values at their defaults, except:

- 'conv_width' = 2x the PSF full width half max (~3.5 pix for ACS/WFC, WFC3/UVIS ~2.5 pix for WFC3/IR)
- 'thresh' = signal-to-noise above background (Start large and reduce until number of objects is acceptable)
- 'searchrad' = fit tolerance (For multi-visit alignment, increase to 3.0", especially for early HST data)

> WARNING: Including more sources does not necessarily give a better solution. All sources are weighted equally in the fit, and the accuracy of centering for faint stars may be biased by CTE tails. Using too low a threshold can also cause TweakReg to pick up hot pixels, and in cases where there are few point sources, the derived offsets will incorrectly reflect the commanded dither pattern. TweakReg can find an acceptable fit with as few as 3 matched sources, though a more ideal number is a few dozen. For star clusters, several hundred or even a thousand bright sources is ideal.

NEW FEATURES in DrizzlePac 2.0 :

- Support for the latest ACS time-dependent distortion
- Support for automated mosaic building. Example here.
- Align different HST cameras in a single step
- Mitigation of false detections
  - Select sources based on sharpness/roundness in order to exclude cosmic-rays
  - Use DQ masks to limit inclusion of artifacts/cosmic-rays by setting new 'dqbits' parameter
- Support for inclusion/exclusion regions for alignment
- Align HST to non-HST images

Useful Diagnostics:

- **Shift file**: When 'shiftfile=True', the computed offsets are written to an output file for inspection.
  Do the offsets make sense based on inspection of the data? (Load frames into DS9, align by WCS, and look for gross offsets).
  Do the offsets reflect the expected pointing accuracy? (A large shift for exposures in the same visit may reflect a poor fit.)

- **Residual plots**: When 'interactive=False', the residual scatter plots (residuals_image.png) and vector plots (vector_image.png) are saved to disk for inspection.

  Scatter plots:

  Residuals should look flat. Any clear slope may suggest that a rotation, scale or skew remains.
  The fit should go through the bulk of the points, with the y-axis centered on 0.0.
  Residuals should not have a hard top or bottom edge. This usually means the sigma-clipping was too aggressive.

Vector plots:
Vectors should map sources in the field. Missing regions could mean 'threshold' or 'sigma' parameters were too large.
Vectors should not show any systematics (e.g. longer on one side of the image or all pointing in the same direction).

- **Fit rms**: At the native plate scale, a 'good' fit is typically less than 0.1 pix rms for ACS/WFC, WFC3/UVIS and ~0.2-0.3 pix for WFC3/IR. The rms is only a guideline and depends on the number of sources and the accuracy of the centering algorithm.
- **Single drizzled products**: Run AstroDrizzle step 3, load *single_sci.fits products in DS9, align by 'image', & blink. Do they line up?

Mitigating Cosmic-Rays:

- Align the visit-level DRZ products, run 'tweakback', and then redrizzle the '*flt.fits' images from all visits
- Turn on the new 'use_sharp_round' parameters in 'imagefindpars' to select sources by sharpness and roundness
- Exclude specific DQ flags from source catalogs with the new 'dqbits' parameter in 'imagefindpars'

Examples:

1: Align a set of UVIS *flt.fits frames to an IR drizzled reference frame:

```
--> tweakreg.TweakReg('@wfc3_uvis_flt.list',\
                      imagefindcfg={'threshold':10,'conv_width':3.5},\
                      refimage='wfc3_ir_f160w_drz_sci.fits',\
                      refimagefindcfg={'threshold':200,'conv_width':2.5})
```

2: Align a drizzled WFPC2 image to a drizzled UVIS reference frame, with user-defined catalogs as input:

```
--> tweakreg.TweakReg('wfpc2_drz_sci.fits',updatewcs=False, catfile='wfpc2.cat',\
                      refimage='uvis_drc_sci.fits', refcat='uvis.coo',\
                      refxyunits='pixels', searchrad=1.0, minobj=4,\
                      updatehdr=True, wcsname='TWEAK')
```

3: Update the WCS with a user-defined shift file derived externally to TweakReg (expert level) **:

```
--> from drizzlepac import updatehdr
--> updatehdr.update_from_shiftfile('shift.txt',wcsname='USER',force=False)

#units: pixels
#frame: output
#form: delta
#refimage: ibnx02asq_single_sci.fits
ibnx02asq_flt.fits  0.00  0.00 0.000 1.0
ibnx14w4q_flt.fits -5.34 -4.97 0.001 1.0
```

**Note that this tool does not allow for skew. Instead, Tweakreg now supports a full 6-parameter fit by setting 'fitgeometry'='general' to correct for any residual skew terms.

Troubleshooting:

- The TweakReg fit r.m.s. is tiny, <0.01 pixels.
  Cause: Software may have locked onto hot pixels and solved for the dither pattern.
  Solution: Reduce 'threshold' to use only the brightest sources.
- Crashes without finding a fit, e.g. 'Too few objects matched'.
  Solution: If a sparse field, reduce 'minobj'. If a crowded field, decrease 'threshold'. If multi-visit, increase 'searchrad'.

AstroDrizzle in a Nutshell

AstroDrizzle removes geometric distortion, corrects for sky background variations, flags cosmic-rays, and combines images with optional subsampling. Drizzled data products from MAST are generated for single visit associations only. To combine data from additional visits, TweakReg should be run first to update the image WCS. Once the full set of images of a given target are properly aligned, they may be combined using AstroDrizzle.

AstroDrizzle consists of four main functionalities:

- Creating a static mask (step 1='**static**')
- Sky equalization (step 2='**skysub**')
- Cosmic-ray flagging (steps 3, 4, 5, 6='**driz_separate**', '**median**', '**blot**', '**driz_cr**'). **Steps may be turned off for WFC3/IR.
- Final combination, with optional subsampling (step 7='**driz_combine**')

NEW FEATURES in DrizzlePac 2.0

- Produce seamless mosaics with a new sky matching algorithm
- Use non-HST (distortion-free) images to define the output reference frame

Examples:

1. Reproduce the pipeline drizzled data products:

- Put the **MDRIZTAB** reference file (*mdz.fits) in your local reference file directory defined above.
- From the GUI: Define the input list (*flt.fits, @inlist) and click 'Update from MDRIZTAB' to fill in instrument-specific defaults. (Parameters values different than GUI defaults will change to **RED**)
- Alternately, from the command line:

```
--> astrodrizzle.AstroDrizzle('*flt.fits', mdriztab=True)
```

Once the MDRIZTAB defaults are loaded, we also recommend changing the following parameters:

- clean=no allow for inspection of output products
- ncores=1 disable parallel processing
- skymethod='match' equalize the sky using only pixels in common between frames
- driz_cr_corr=True allow for inspection of cosmic-ray masks

2. Combine a set of calibrated ACS frames with sky matching and cosmic-ray rejection, and set the output reference frame to match a drizzled UVIS image:

```
--> astrodrizzle.AstroDrizzle('*flc.fits', output='acs_f555w', skymethod='match',\
                      driz_sep_bits='96', driz_cr_corr=True, final_bits='96',\
                      final_wcs=True, final_refimage='uvis_f5555w_drz_sci.fits')
```

Data Quality flags:

- CALxxx software sets various flags in DQ array of calibrated images
- These flags can be used as bit masks to reject pixels with specific DQ values.
- Users can control this using the drizzle parameters: 'driz_sep_bits', 'final_bits'.
- The GUI default (*_bits=0) will treat every non-zero pixel in the DQ array as bad. (This is usually too aggressive.)
- Recommended values: WFC3/IR= '64,512', ACS/WFC & WFC3/UVIS= '32, 64', WFPC2= '8, 1024'. These tell the software which flags to instead treat as good.
- Alternately, a 'tilde' can be used to reverse the meaning... eg. which DQ flags to treat as bad. For example, to reject only cosmic rays: final_bits= '~4096'

Optimizing the sampling:

- Select a 'final_scale' value that is ~2x the full width half max to allow for adequate sampling of the PSF
- Select a 'final_pixfrac' value that is slightly larger than the 'final_scale' to allow for spillover when drizzling
- The more dither positions, the more you can shrink the 'final_pixfrac'
- In a small region of the weight image, compute the standard deviation divided by the mean . Shrink 'final_pixfrac' until the ratio is no larger than ~0.2.

Weighting:

- For Poisson-limited targets such as star clusters, use exposure (EXP) weighting
- For background-limited targets, such as deep fields, use inverse-variance map (IVM) weighting

Useful Diagnostics:

- Blink the drizzled science (*drz_sci.fits) and weight (*drz_wht.fits) images
    - For EXP weighting at the native plate scale, the weight value should reflect the total exposure time.
    - There should be no 'holes' in the weight image, e.g. pixels with zero weight. For any holes that correlate with known DQ flags, try less aggressive bit masks.
    - Low weight values that coincide with the sources in the science data suggest that cosmic-ray flagging may need to be fine-tuned (see below)
- Blink the original calibrated images (*flt.fits) with the cosmic-ray masks (*crmask.fits)
    - Do the masks under-predict the number of cosmic-rays? Try lowering 'driz_cr_snr'
    - Do the masks flag bright sources? Try raising 'driz_cr_scale'. Else, recheck the sky background and/or alignment.
- Inspect the ellipticity and radial profile of the PSF across the frame to look for any anomalies.

Troubleshooting:

- Computer freezes when running AstroDrizzle
  Solution: Set 'num_cores'=1 to disable parallel processing
- Background mismatch between frames
  Solution: Try using skymethod='match' instead of 'localmin'
- Science image looks noisy.
  Cause: Sky not properly estimated? Pixfrac set too low?
- Low values in weight image coincide with point sources.
  Cause: Poor alignment? Poor sky matching?
- Strange 'moire' pattern in the sky background
  Cause: Drizzling introduces correlated noise when resampling the pixels and convolving with an output kernel. (This is most noticeable in single frames and is not indicative of an error).
- Detector artifacts (hot pixels, IR blobs) in drizzled data
  Solution: Experiment with bit mask settings using 'driz_sep_bits' and 'final_bits'.