AstroDrizzle: Aligning Images From Multiple Instruments

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Abstract

DrizzlePac is the new software package for aligning and drizzling Hubble Space Telescope images. It is a substantial improvement on the current MultiDrizzle package. In particular, the handling of astrometry has been revamped to make use of SIP and Paper IV standards. This software will replace the STSDAS Dither package. We present an example where we use the TweakReg task to align images from multiple HST instruments: WFPC2, ACS/WFC, WFC3/UVIS, WFC3/IR. Even though each instrument and set of observations has different characteristics (plate scales, distortion, rotations, epochs, etc.), Tweakreg makes it easy to align them to within ~ 0.01" accuracy. This type of work will be of benefit to the many archival users who analyze datasets taken with different HST instruments.

Discussion

All data used in this example are archival data. All datasets were downloaded from the Mikulski Archive at Space Telescope (MAST) with bias, dark, and flat field corrections already applied. Table 1 summarizes basic information for the datasets. The data comes from four different HST instruments, 7 different filters, spanning 14 years, and different orientations. Because of the pointing accuracy of the telescope, and because different guide star catalogs were used during different epochs, the pointing of the images can be off by as much as a few arcseconds (Gonzaga et al., 2012).

The tasks included in DrizzlePac make it easy to align these images to a common reference frame. DrizzlePac offers different methods and tools to align images. Images can be aligned directly using TweakReg, which finds sources in each individual image and uses them to refine the alignment and update the WCS information. Combined drizzled images from different pointings or filters can be aligned with each other. The solution can then be "trickled down" to the individual input images using 'tweakback' (see poster 135.12 by J. Mack).

For this mosaic, only DrizzlePac tools were used to perform the image alignment. A single image from the F814W set was chosen as the reference frame. Cosmic-ray cleaned versions of the individual images in each filters were aligned to the reference frame. Once the solution was found, a headerlet was created. Headerlets are compact FITS files that contain the WCS solution for a single exposure that has been aligned to a particular image or astrometric catalog, complete with all the distortion information. The headerlet solution was then applied to the original image. Finally, we combined each filter set using AstroDrizzle. WFPC2 and WFC3/IR images were drizzled to a scale of 0.08"/pix, ACS and WFC3/UVIS were drizzled to a scale of 0.04"/pix.

Alignment Accuracy

We used the PHOT task in the DAOPHOT package (Stetson, 1987) to find and measure sky positions of 422 bright stars in the ACS/F814W combined image. The positions of those stars were then measured in each of the other combined images and compared to the reference frame.

Because of the varying colors of stars, differential extinctions, crowding, and depth of each image, not all sources were detected in all images. The catalogs for each filter had to be cleaned for position measurement flags. In addition, any measurement with an offset greater than 1 pixel (in the drizzled image scale) was thrown out as a bad detection. Table 2 shows the number of stars detected in each filter and included in the offset measurements.

Figure 1 shows the mean offsets for stars measured in each filter. All filters are aligned within 0.01" of the reference frame.
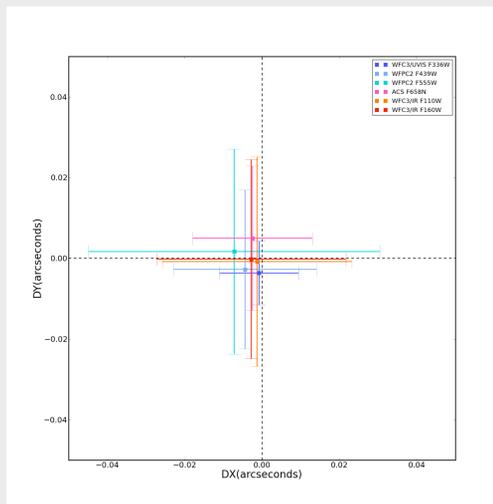

Figure 1 - Residuals of positions measured from the drizzled combined images. In every case the images are aligned to within 0.01 arcsecond.

Filter	Camera	# of Stars
F336W	WFC3/UVIS	168
F439W	WFPC2	377
F555W	WFPC2	27
F658N	ACS/WFC	37
F110W	WFC3/IR	387
F160W	WFC3/IR	384

Table 2: Number of stars used in each filter for measurements of the alignment accuracy.

References

- Gonzaga, S., Hack, W., Fruchter, A., Mack, J., eds. 2012, The DrizzlePac Handbook. (Baltimore, STScI)
- Stetson, P.B., 1987, PASP, 99, 191

Cookbook

1. Use 'updatewcs' to apply the geometric distortion information in SIP and Paper IV convention

2. Produce cosmic-ray cleaned versions of input images using AstroDrizzle

3. Use TweakReg to align CR cleaned images to reference frame and create headerlet containing updated WCS solution

4. Apply headerlet solution to original images

5. Drizzle images using AstroDrizzle

Filter	Camera	Plate scale("/pix)	Obs. Date	Exp. Time(sec)	Rot. Angle(deg)	Prop ID
F336W	WFC3/UVIS	0.04	2010-01-27	11032	-177.25	11577
F439W	WFPC2	0.10	1996-01-20	4000	-30.31	5962
F555W	WFPC2	0.10	2008-12-01	17500	-25.15	11962
F658N	ACS/WFC	0.05	2004-07-21	2300	118.47	10188
F814W	ACS/WFC	0.05	2004-07-21	1680	118.47	10188
F110W	WFC3/IR	0.13	2010-01-22	3598	179.63	11577
F160W	WFC3/IR	0.13	2010-01-22	5996	179.63	11577

Table 1: Summary of observations used in this example. The plate scale information for WFPC2 refers to the WF chips.

WFC3/UVIS F336W *U*
WFPC2 F439W *B*
WFPC2 F555W *V*
ACS/WFC F658N Hα
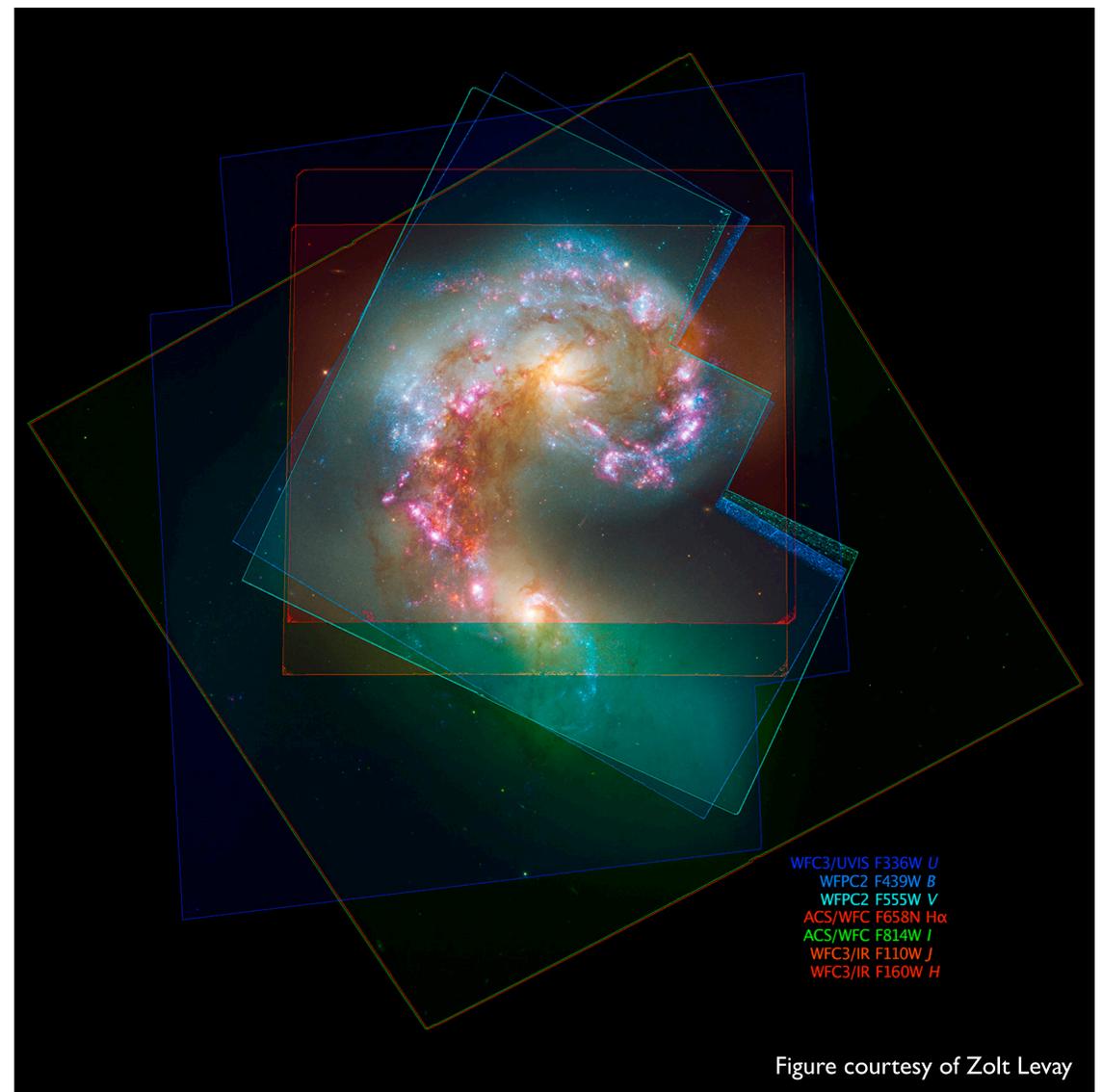ACS/WFC F814W *I*
WFC3/IR F110W *J*
WFC3/IR F160W *H*

Figure courtesy of Zolt Levay

Figure 2 - Seven color image of the Antennae Galaxy (NGC4038/4039). Outlines show the footprints of each instrument on the sky. North is up and east is to the left.