WFC3RED

A HST Wide Field Camera 3 Image Processing Pipeline

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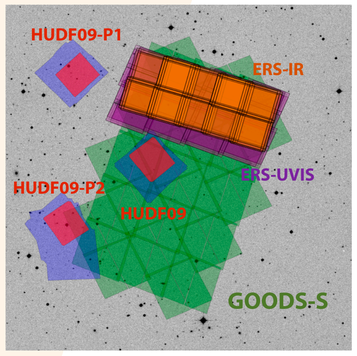
Abstract

WFC3RED is an automatic image processing pipeline for data taken with the Wide Field Camera 3 (WFC3) instrument on the Hubble Space Telescope (HST). The pipeline currently supports processing of imaging data from both the IR and UVIS channels and is written in Python and C. The automated processing steps include cosmic-ray removal (UVIS), super-sky subtraction, user defined artifact masking, robust alignment and registration for large mosaics, weight map generation, and drizzling onto a final image mosaic. WFC3RED can combined data across different HST observations, visits and proposals without the need for any pre-defined associations. WFC3RED can create image products with a signal-to-noise ratio that matches the most careful step-by-step manual WFC3 reductions.

Introduction

The WFC3 was installed during HST Servicing Mission 4 (SM4) by the Space Shuttle astronauts in May 2009. After several months of on-orbit verification WFC3 began operations in the summer of 2009. Some of the first observation were taken from the Early Release Science (ERS) and the Hubble Ultra Deep Field 2009 (HUDF09) projects. The HUDF09 project was awarded 192 orbits of HST WFC3/IR observations in the GOODS South field consisting of 3 pointings covering previous optical HST ACS observations with about half of the orbits covering the Hubble Ultra Deep Field ACS pointing.



The HUDF09 WFC3/IR image is the deepest image of the universe ever taken in the near-infrared light.

In order to quickly process the large amounts of imaging data provided by the HUDF09 & ERS programs we developed an automatic image reduction pipeline required for processing all HST WFC3 observations in these 5 areas. The HUDF09 project pipeline-processed data will made publicly available through the Multi-Mission Archive at STScI (MAST) as high level science products.

Pipeline Modules

The WFC3RED pipeline includes eight processing steps to generate final co-added registered mosaics. Due to its modular architecture new processing modules can easily be added for additional calibration or to correct for unwanted effects.

Module	Description
`setup`	Ingest raw data and builds a SQLite database containing fits header data
`medsub`	Subtracts a median stacked super-sky image
`flatten`	Corrects background over-subtraction near bright objects
`definemask`	Apply user defined masks & persistent image masks (optional)
`align`	Determines internal and external image alignment
`weightmap`	Creates accurate rms maps for MultiDrizzle
`mdrizzle`	Creates final CR cleaned drizzled images using multidrizzle
`refineshift`	Refines the WCS (if needed)

Running WFC3RED

WFC3RED has a number of runtime options:

- Modules can be run automatically (default) or sequentially one-by-one
- A pipeline run can be stopped, restarted or rerun at any module after the initial setup module is run
- Use an external reference image for alignment
- Single image CR cleaning data before alignment (UVIS only)
- Group and combine observations by visit for CR cleaning then align (UVIS only)
- Input is flt.fits files which can be obtained through the MAST HST archive.

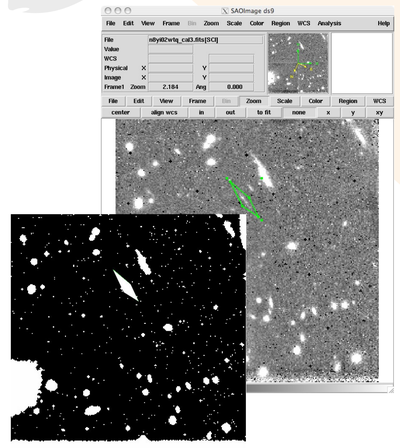
```
Usage: wfc3red.py run_name flt_in_dir

Options:
  --version             show program's version number and exit
  -h, --help            show this help message and exit
  --setup               run setup only
  --definemask          interupt to run definemask
  --flatten             run flatten only
  --medsub              run medsub only
  --align               run align only
  --weightmap           run weightmap only
  --mdrizzle            run mdrizzle only
  --refineshift         run refineshift only
  -a ALIGNREF, --alignref=ALIGNREF
                        external reference image used for alignment (absolute
                        path)
  -n MODULE, --rerun=MODULE
                        rerun wfc3red from MODULE on
  -r, --restart         restart wfc3red
  -s SKIP, --skip=SKIP  Skip running module/s
  -t TARGNAME, --targname=TARGNAME
                        run wfc3red only on images with name TARGNAME
  -f FILTER, --filter=FILTER
                        run wfc3red only on images with filter name FILTER
  --pixel_scale=PIXEL_SCALE
                        pixel scale (in arcsec/pixel) for final drizzled
                        images (default=0.06 for IR 0.0396 for UVIS)
  --pixel_frac=PIXEL_FRAC
                        pixel fraction for final drizzled images (default=0.7)
  --drz_kernel=KERNEL   drizzel kernel for final drizzled images
                        (default=square)
  --nomasking           turn off masking
  --noskysub            turn off multidrizzle sky subtraction
  --nodrzcr             turn off multidrizzle cosmic ray rejection
  --brightobj           take several actions to better cope with bright
                        objects
  -d DRZREF, --drzref=DRZREF
                        external reference image used for final drizzle
                        (absolute path)
  --tshift=TSHIFT       external reference shift file used for final drizzle
                        (absolute path)
  -c, --crclean         cosmic ray clean UVIS images before running align
                        (helpful for UV data)
  -e, --sparse          skip align and cosmic ray clean UVIS images by visit
                        (helpful for UV data)
```

Masking Artifacts

User defined mask can be generated using SAOimage DS9:

- Images are displayed in DS9
- The user marks artifacts with DS9 polygon region tool
- A script is run that saves a DS9 region file for each image which has a marked artifact
- A second script is run that applies the masks region in each region file to the associated image's data quality.

This tool is useful for masking artifacts such as satellite trails.



What's next?

- We currently expect to have a public release of WFC3RED by mid-2011
- Implement a multi-cpu WFC3RED version
- Add the ability to build on previously processed dataset without having reprocess all data

Thanks to:

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The HUDF09 project team members are Garth Illingworth (University of California Observatories/Lick Observatory and the University of California, Santa Cruz), Rychard Bouwens (Leiden University), Pascal Oesch and Marcella Carollo (Swiss Federal Institute of Technology, Zurich (ETH)), Marijn Franx (Leiden University), Ivo Labbe (Carnegie Institute of Washington), Daniel Magee (University of California, Santa Cruz), Massimo Stiavelli (Space Telescope Science Institute), Michele Trenti (University of Colorado, Boulder), and Pieter van Dokkum (Yale University).