A HST Wide Field Camera 3 Image Processing Pipeline

Abstract
WF3RED 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. WF3RED can combined data across different HST observations, visits and proposals without the need for any pre-defined associations. WF3RED 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.

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.

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
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<tbody>
<tr>
<td>setup</td>
<td>Ingest raw data and builds a SQLite database containing fits header data</td>
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<tr>
<td>medsub</td>
<td>Subtracts a median stacked super-sky image</td>
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<tr>
<td>flatten</td>
<td>Corrects background over-subtraction near bright objects</td>
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<tr>
<td>definemask</td>
<td>Apply user defined masks &amp; persistent image masks (optional)</td>
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<tr>
<td>align</td>
<td>Determines internal and external image alignment</td>
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<tr>
<td>weightmap</td>
<td>Creates accurate rms maps for MultiDrizzle</td>
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<tr>
<td>mdrizzle</td>
<td>Creates final CR cleaned drizzled images using multidrizzle</td>
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<tr>
<td>refshift</td>
<td>Refines the WCS (if needed)</td>
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Running WFC3RED
WF3RED 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 fits/fits files which can be obtained through the MAST HST archive.

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 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

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