Quality Fits in the Astro-Wise Environment

Astro Wise Group - INAF OAC

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1 QualityFITS Overview

The QualityFITS has been developed by Frederic Magnard, in C and Perl. It is a fully-automatic, "memoryless" process (its behaviour does not depend on past history): at TERAPIX it is directly part of the data reception stage. Minimal WCS info (approximate pixel scale and image location and orientation), approximate zero-point and effective wavelength are required for working (predefined values can be used). The goal of the QualityFITS is not to take decisions about the quality of images but generate weight-maps and flag maps (quality control at the pixel level), and produce stats about sensitive image parameters (quality control at the exposure level).
QualityFITS performs the following steps on preprocessed (debiased and flat-fielded) images (named base.fits):

1. runs SExtrator for cosmic ray identification; a FITS mask is produced
2. runs weightwatcher using a flat-field (weight map), the cosmic ray mask, detector mask and the input image to produce a weightmap and a flag map (a dummy constant flat field is produced if none was found)
3. runs SExtractor with a low threshold for stellar and galaxy count histograms, and eventually for further astrometric and photometric calibration
4. runs SExtractor with a higher threshold to identify bright sources to measure the instrumental PSF
5. runs psfex to construct a PSF model from the sources catalogue extracted in 4
6. runs mefhisto which plots histograms of CCD backgrounds, stars and galaxy counts, and writes a FITS table containing CCD backgrounds, FWHM, number of detected sources and other useful quantities. See below for details.
7. run swarp (resampling and stacking) on the whole mosaic to build a single FITS image. SExtractor is run again on this image to make a plot of the PSF ellipticity of the whole mosaic. This feature is time consuming and it is disable by setting $config{ellipt} to 0 in the configuration file, or with the command line option –disable-ellipticity

8. makes PNG images of the whole mosaic of the original image, the weightmap image and the PSF model. Additional PNG images are also built for each CCD frame with a 4x4 binning factor.

9. these images and quantites are summarized in a webpage

The FITS files produced by QualityFITS, which can be used for later astrometry/photometry/swarping are :
base_weight.fits: weight map, useful for later co-addition.
base_flag.fits: flag map, allow statistic on image quality.
base.ldac: source catalogue.

1.1 Mefhisto Overview

In the QualityFITS there is a program called mefhisto that opens tables produced by SExtractor and pfsex in QualityFITS pipeline to plot statistic histograms. It works on MEFs.
It produces a FITS table, an histogram of the background over the CCDs of the mosaic, an histogram of the FWHM over the CCDs, an histogram of star counts over all CCDs and an histogram of galaxy counts over all CCDs.
Standard output shows a summary of the statistics.
A FITS binary table (base_diag_bin.fits) has the following columns for each CCD:

- background level in ADU (background)
- standard deviation background (sigma_bkg)
- number of sources detected by SExtractor (nsexdet)
- seeing (FWHM) in pixels (seeing)
- number of sources loaded (sloaded) by psfex for FWHM calculation
- number of sources accepted (saccepted) by psfex for FWHM calculation
- final chi square of the PSF fit (schi2).

The main dependencies (plplot and cfitsio) are included in the package,so they do not need to be installed.
Mephisto can use a filter definition file (filter.dat) that includes zero points, mean sky background (not used) and a fit to a galaxy count histogram (to be used as a visual reference line).
filter.dat contains the follow columns:

- filter ID (from FILTER FITS header card, must match exactly, case sensitive)
- zero point in this filter band, per second
- units of the zero point: electron (EL) or ADU (ADU)
- expected sky background (not used)
- d(log(N))/d(mag) : fitted slope of galaxy count histogram

- galaxy count histogram zero point
- sky coverage in degree of the fitted galaxy count survey
- lower magnitude used for the fit
- upper magnitude used for the fit

2 Dependencies

QualityFITS is written in Perl (QualityFITS.pl and www_build.pl) and in C (xml.c a program that builds the xml pages and mefhisto.c that uses cfitsio library). The Perl Code calls the Terapix (Emmanuel Bertin)'s software suite : SExtractor, Weightwatcher (ww), SWarp, Psfex, Stiff and for each call uses a different configuration file moreover the main config file is ./usr/local/etc/qualityFITS.rc unless this option is given.
In the AstroWise Pipeline Environment at moment are not present weightwatcher (ww), psfex and stiff.

- WeightWatcher (or simply WW) is a program that combines weight-maps, flag-maps, and vector data in order to produce control maps which can directly be used by astronomical image processing packages.
- psfex: Point Spread Function Extractor (Not Public: there is no documentation)
- STIFF is a program that convert scientific FITS images to the more popular TIFF, in 8 (grayscale) or 24 (true colour) bits per pixel.

3 Some interesting ideas

The QualityFITS contains several original and useful quality control tools:

- Diagnostic summary stats published in FITS (binary table) and XML formats
- Plots and Thumbnails published in both PNG and Postcript formats
- Support both basic FITS files and MEFs
- Provide binned image and weight-map thumbnails in PNG (lossless) format.
- Provide thumbnails of low-surface brightness maps of the background.
- Generate a tabulated model of the PSF for each CCD.
- Track background level, background noise, source density and PSF variations across the field of view.
- Provide rough star and galaxy count histograms.

These quality control results require always the human check (Human QC) to understand if there are problems in the images.
In order to integrate qualityFITS in the Astro Wise environment it would be better to remove redundant parts (weight and flag maps creation). On the other hand weight and flag maps are used by qualityFITS which, therefore, must be placed after the production of weight and flag maps by the Astro Wise pipeline. Moreover, as qualityFITS uses zero points [1] to create star/galaxies count histograms, it would be better to use the real zero points calculated by the photometric pipeline. This aspect means that QualityFITS must be run after the photometric pipeline.
An other more serious problem is given by the parallelization: QF works on MEFs whereas the Astro Wise pipeline works on single CCDs in parallel. This means that some functionalities (stars/galaxies count summed over all CCDs, PSF ellipticity over the whole mosaic) of qualityFITS are not usable in the Astro Wise parallel scheme and would require deep modifications of the software in order to have them working.
In the Astro Wise context the most interesting results from qualityFITS are instrumental PSF for each CCD and fits tables produced by Mephisto that contain CCD background, stars and galaxy counts and FWHM. For what concerns the web pages this is probably not essential for our purposes as we can save all the results directly in the database.
The Astro Wise pipeline should include the ORIGIN keyword when writing FITS headers. In fact these information are crucial for QualityFits to elaborate the data.

4 Compatibility

To work correctly qualityFITS requires the latest version of Swarp 2.5 but the pipeline currently uses a beta version of Swarp (swarp 2.0b see opipe/README) that fails to create usable weight images. Reasonable weight images are essential to obtaining a fast computing-time with cosmicfits, and are crucial when the frames on which cosmic rays are detected have strong intensity slopes.
It would be better to keep an update list of the software needed for the pipeline; in fact the file README doesn't mention new upgrade about python, Swarp and the right version usable. Moreover, for what concern Psfex, there is not yet any public release and documentation.

[1] The QualityFITS uses the zero points to create star/galaxy count histograms if are not present, the header value of the keyword PHOT_C or ZEROPNT is used. If the keywords EXPTIME, PHOT_K (or EXTINCT) and AIRMASS (or mean of AIRMSTRT and AIRMEND) are found in the header, the quantity $2.5 * log10(EXPTIME) - (PHOT\_K|EXTINCT) * (1 - AIRMASS)$ if ORIGIN==CFHT or the quantity $2.5 * log10(EXPTIME) - (PHOT\_K|EXTINCT) * AIRMASS$ otherwise is added to get the final zero point. If not given via this option, and PHOT_C not found in the header, the value corresponding to the FILTER is taken from filters.dat, and substrated by $2.5 * log10(GAIN)$ if its unit is EL.