omfchain

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Abstract

This document describes the use of the Optical Monitor Fast mode SAS processing software to extract light curves from Fast mode observations.

1 Instruments/Modes

Instrument	Mode
OM	fast

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

This package contains a PERL script which takes a set of fast mode OM ODF files in a single directory and processes them in a pipeline to produce OM fast mode products. Given a directory with a set of ODF files that conform to the filename specification given in the ODF ICD the PERL script will process the fast mode event list files. The chain produces images of the sources found in OSWs, determines regions for the sources and background, extracts events related to the source and background, and constructs corresponding lightcurves.

3.1 Calibration set-up

Before processing OM data, it is necessary to create a calibration index file (e.g. *ccf.cif* file) using the SAS task, *cifbuild* – it is probably best to create it in the ODF directory.

3.2 Flat-field

A flat-field file required by the Fast chain. It was originally envisaged that flat-filed images, generally obtained during spacecraft slews or periods when the OM is inactive, would be stored in an archive.

This was intended, partly to monitor the evolution of the detector response and also to allow users to accumulate a statistically good flat-field from flats taken close in time to their observations. However, for a number of reasons this has so far proved unnecessary and a single OM flat-field is to be stored as a component of an OM Calibration File (OM_PIXTOPIXSENS). Due to the complexity of analysing the OM flat-field, at the current time the stored flat is a unit image (which is a reasonable apptoximation to $\approx 5\%$). This will be superceded by a 'real' flat once better understanding of the flat-field variations and the gross response are attained. At present a warning will be issued noting that a template (i.e. a unit flat-field) is being used. This flat-field is created automatically within *omfchain*.

3.3 Fast data types

Fast mode data is taken in a single format, arriving as an event list. In a given exposure up to two Fast mode windows may be defined, each giving rise to a separate event list. One should be aware that Fast mode data may be accompanied by Image mode windows from the same exposure.

3.4 Fast chain capabilities

The Fast mode chain processes only event lists. It internally builds tracking shifted and field-corrected images of the Fast mode windows. These are searched for sources, and light curves for any detected objects are extracted from the event list files. If more than one source is detected within the window, the output data set will contain a light curve for each source.

3.5 Fast chain tasks

The Fast chain works in the following way:

- When starten *omfchain* creates indexes of the optical monitor fast mode data set files presented in the input directory.
- If *flat field* files (FFX) are not found, *omfchain* creates an empty flat field file
- If *periodic* or *non-periodic housekeeping* files are not found in the input directory, the chain is stopped.
- If *tracking history* files (THX) are not found for the given exposure, the chain creates a dummy tracking history file.
- For each observation, as well as for each exposure and scientific window, *omfchain* produces intermediate and pipeline output files according to the following scheme.

The following tasks are used by the Fast chain:

No.	Task	Input files (coming from)	Output files (going to)
1	omprep	in→ Tracking history, in→ Periodic house keeping, in→ Non-periodic house-keeping, in→ Window data	Temporary tracking history → 2,6
2	omdrifthist	1→ Temporary tracking history	Tracking history plot →out
3	omthconv	in→Non-periodic house-keeping	Tracking history timeseries →out
4	omprep	in → Event list, in → Periodic house keeping, in → Non-periodic house-keeping, in → Window data	Intermediate event list →5,6
5	evselect	4→ Intermediate event list	Output raw image →out
6	omfastshift	1→ Temporary tracking history, 4→ Intermediate event list	Corrected event list→ 7,11,12
7	omfastflat	in→ In-orbit flat-field, 6→ Intermediate event list	PPS image →8 PPS flat-field →out
8	omdetect	7 → PPS image	Source region (ASCII-file) →9 OSW source list →9,10
9	omatt	8→ Source region 8→ OSW source list	Sky coordinate PPS image →out
10	omregion	8→ OSW source list	Source region →11,13 Background region →12,13
11	evselect	10→ Source region 6→ Intermediate event list	Source rates table →13
12	evselect	10→ Background region 6→ Intermediate event list	Background rates table →13
13	omlcbuild	11→ Source rates table 10→ Source region 12→ Background rates table 10→ Background region	Light curve table →14
14	lcplot	13→ light curve table	Light curve postscript plot →15
15	ps2pdf	14→ Light curve postscript plot	Light curve →out PDF-plot

4 Parameters

This section documents the parameters recognized by this task (if any).

Parameter	Mand	Type	Default	Constraints
inpdirectory	no	string	none	

Directory path-name of the input files directory - defaults to the current directory.

outdirectory	no	string	none	

Directory path-name of the output files directory - defaults to inpdirectory

boxscale	no	int	2	boxscale≥ 1

Sliding box size for detection by *omdetect*

contrast	no	real	0.001	contrast≥ 0

Contrast parameter for the source detection algorithm (it is O.K. if $flux \geq confusedsource/totalflux$

maxscale	no	int	1	maxscale≥ 1

Maximum power of 2 to search to by *omdetect*

nsigma	no	real	6	nsigma≥ 1

Number of σ for source detection by *omdetect*

smoothsize	no	real	64	1 ≥smoothsize≥ 264

Smooth size (in pixels) used for smoothing image and background by *omdetect*

srcradius	no	real	−10	−12 ≥srcradius≥ 12

Radius of the source extraction circle. If it is negative, it is expressed in pixels, and its value will be fixed during the extraction of counts. If it is positive, it is expressed in FWHMs, and its value could be reduced by *omregion* if there is any contaminating source near by the target.

bkginner	no	real	1.2	bkginner≥ 1

Inner radius of the background annulus in terms of source radius (*srcradius*)

bkgouter	no	real	1.8	bkgouter≥ 1

Outer radius of the background annulus in terms of source radius (*srcradius*)

timebinsize	no	real	10	timebinsize≥ 0.5

Size of the time bins (in seconds) for the time series files

All parameters are optional.

5 Input Files

Before attempting to use the *omfchain*, first run the *odfingest* SAS task. This will create a *SUM.SAS file from *SUM.ASC file that comes with the ODF. It is better to keep this in the same directory as the ODF. With this, and the other files listed below, which should already be in the ODF, it should be possible to process the OM Fast mode event list files.

1. rrrr_iiiiiiiii_SCX00000NPH.FIT - OM Non-periodic Housekeeping file
2. rrrr_iiiiiiiii_SCX00000PEH.FIT - OM Periodic Housekeeping file
3. rrrr_iiiiiiiii_SCX00000FFX.FIT - PPS OSW Flatfield Image
4. rrrr_iiiiiiiii_SCX00000TCS.FIT - Spacecraft time correlation file
5. rrrr_iiiiiiiii_SCX00000ATS.FIT - Spacecraft attitude history file

For each exposure to be processed there are also files:

1. rrrr_iiiiiiiii_OMSeeewwTHX.FIT - OM Tracking History Data Auxiliary file
2. rrrr_iiiiiiiii_OMSeeewwFAE.FIT - OM Fast Mode Event List file
3. rrrr_iiiiiiiii_OMSeeewwWDX.FIT - OM Priority Window Data Auxiliary file

where **rrrr** is the 4 digit XMM rev. number, **iiiiiiiii** is the 10 digit observation id, **eee** is the exposure number (e.g. 006 etc.), and **ww** is the window identifier (00 or 01).

If **THX**-file are not present, no tracking corrections can be applied but this is often not critical since XMM's tracking apperars to be good to around 1 arc-second. If **THX** files are absent, a dummy file is created by *omprep* - this this the default action of *omfchain*.

Often a raw image FIT-file corresponding to the OM Fast mode window is also present in the input data set, as well as a larger image corresponding to the OM imaging window for the same exposure (rrrr_iiiiiiiii_OMSeeewwIMI.FIT), but these files are not used for the Fast mode chain.

6 Output Files

1. PPS Tracking History Plot - Postscript
2. PPS Track Star Time Series - FITS
3. PPS PSF
4. PPS OSW Image
5. PPS OSW Sky-coord Image
6. PPS OSW Sky Source List
7. PPS Observation Sky Source List
8. PPS Source Region file
9. PPS Background Region file
10. PPS Source Rates file
11. PPS Backgroun Rates file
12. PPS Lightcurve timeseries file
13. PPS Lightcurve Plot file - Postscript
14. PPS Lightcurve Plot file - PDF

7 Running The Pipeline

The location of the ODF files is specified by either setting the environment variable SAS_ODF (setenv SAS_ODF directory-path), or by specifying the input directory (omfchain inpdirectory=directory path), or by setting the environment variable SAS_ODF to a SAS summary file. For the latter, the omfchain will extract the directory path from the SAS summary file. Note that SAS-ODF should actually be SASunderscoreODF- latex objects to underscores).

1. Use command 'omfchain' to process the ODF data set in the current directory or to where SAS_ODF has been set to, and to place the product files in the current directory.
2. Use command 'omfchain inpdirectory=input-directory-path' to process the OM ODF data set in the specified directory, and to place the product files in the current directory.
3. Use command 'omfchain outdirectory=output-directory-path' to process the ODF data set in the current directory or to where SAS-ODF has been set to, and to place the output files in the specified directory.
4. Use command 'omfchain inpdirectory=input-directory-path outdirectory=output-directory-path' to specify both the location of the ODF data set and the directory where the product files are to be placed.

Apart from the initial automatic creation of the flat-field image, the *omfchain* can be considered as being divided into 4 subsequent stages for processing each window/event list (see figure 1).

1. Tracking history information is turned into graphic products and a file used by the event-list analysis part of the chain.
2. A tracking-shift and flat-field corrected image is created from the event list.
3. The image is source-searched and appropriate extraction regions defined.
4. Background-subtracted light-curves are derived (on a per-exposure basis) for each source from the event list and graphical products are generated.

These four processes run inside a loop over all exposures and all windows. In addition, the last step is executed for all detected sources within each window (see figure 1).

8 Comments

- If the chain runs to completion, a number of important output files will appear. The chain product filenames have the extension '.FIT'. The names of the files start with 'P' for the products and with 'F' for the intermediate images and timeseries.
- The use of the parameters for the source and background extraction areas requires some care. Although the source extraction region is simply a circle, the undersampled nature of the OM PSF means that the circle has a small radius and thus encompasses only a few pixels. Pixels on the circle edge therefore contribute a substantial fraction to the area, and πr^2 may not be a good approximation to the extraction area. Furthermore, the background extraction region is an annulus, possibly with circular areas excluded (see the OMREGION task description), and these excluded circles are not necessarily totally enclosed by the annulus. In addition, the FAST-mode OM window is small, and a part of the source and

background areas falls out of this window. The source and background counts should be scaled to the CAL circular area in order to correct them for the coincidence loss. This scaling is sensitive to the currently used OM PSF. If the source and background areas are affected by the source proximity to the edge of the OSW or if the real OM PSF differes from that, taken from the current calubration file (CCF), than the OMLCBUILD output count rates could vary from exposure to exposure for the same source. The effect could be increase for bright sorces due to the 8-pixel pattern noise. In order to avoid these variations and to obtain a uniform combined light curve, it is better to use a fixed radius for the source extraction area for all the exposures in the ODF. This radius should not be less than 6 pixels. This is currently used as the default value for the chain in order to get better signal-to-noise ratio. One may change this parameter by using the command 'omfchain srcradius=...'. If *srcradius* is set to a negative value, it will be fixed while processing all the exposures (its default value is negative). Changing *srcradius* parameter one should also properly esablish the background extraction area setting *bkginner* and *bkgouter* parameters (see description of the parameters).

- A few output files (P* files) from *omfchain* should be checked. A useful first step is to inspect the output PDF-light curve plots to check that the data are sensible - watch out for frequent drop-outs, isolated high or substantial negative values. Establish that the background light curve is reasonable. One should also examine the image of the Fast mode window, for example, with the ftool, *fv*. Check whether the source is well centred or close to an edge. If the latter, inspect the light curves, especially from fifferent exposures, to see if the separate exposure-based light curves are plausibly consistent (bearing in mind any intrinsic source variability). If the image appears blurred or odd in any way, look at the tracking history file to see whether tracking was reliable. You may also want to overlay the image source list onto skymap using*implot*, e.g.

  implot set= sky_image_file.FIT **withsrclistset=y srclistset=**osw_source_list_file.FIT **device=**your_device (e.g. **/XW**) **itv=1 radius=3 maxsrc=10 colour=7**.

  While often there will be only one object in the image, one should check for spurious detections, which could affect the analysis of the target source and also for missed sources or prominent objects in the window, which may contaminate the target. At the current time, bright contaminating sources are not treated properly, and, if present, affect the light curve of the target (and vice versa) - this will be rectified in a future version of the relevant SAS tasks. It is possible to change the detection efficiency via the **boxscale**, **smoothsize**, **nsigma**, and **contrast** parameters.

9 Future developments

In order to overview light curves of all exposures of the same source it would be convenient to construct and plot in one graph a combined light curve of the source.

References

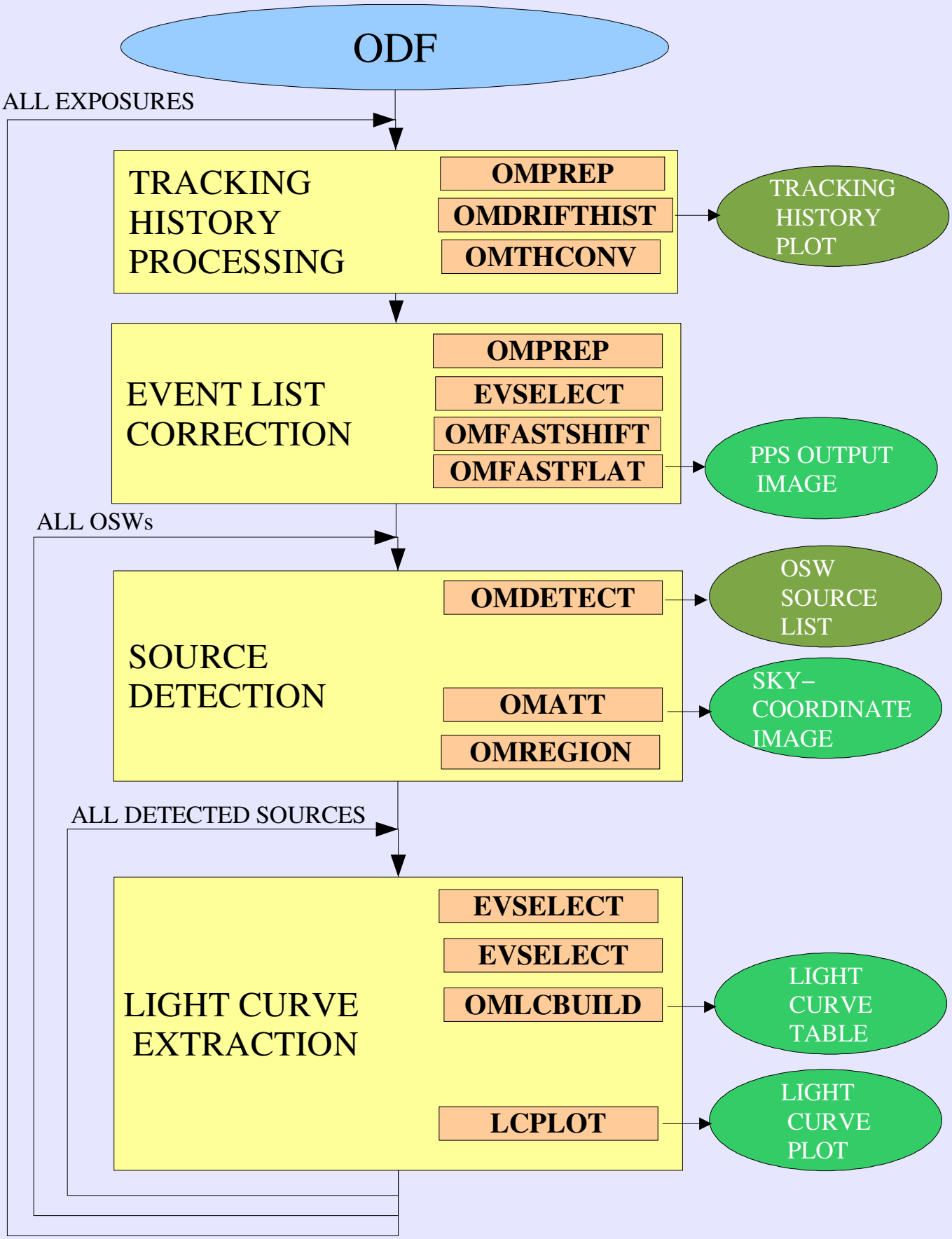

Figure 1: OM Fast Mode Pipeline