attfilter

August 16, 2005

Abstract

Exposure-specific attitude data filtering and GTI creation

1 Instruments/Modes

Instrument	Mode
all	all

2 Use

pipeline processing	yes
interactive analysis	yes

3 Description

attfilter performs exposure-specific attitude data filtering and Good-Time-Interval (GTI) creation driven by a single boolean selection expression. The task generates a single GTI table whose rows represent time intervals during which the spacecraft attitude did not deviate from a given reference attitude by more than a specified tolerance limit. Thus, filtering an event list with this GTI table will eliminate all events that have been detected during times of unfavorable attitude, e.g., short pointing excursions due to loss of guide star(s) by the star tracker system. Although the aspect correction tasks in the SAS, viz. **attcalc** (EPIC), **rgsangles** (RGS), and **omatt** (OM) can correctly treat even large attitude variations[1] attitude GTI filtering is deemed crucial in order to avoid the generation of unnecessarily large sky images and exposure maps and to reduce variability due to sources moving across the face of the detector (e.g. crossing chip gaps, changing vignetting). In the case of RGS this processing step is especially important since the scientific quality of the calibrated event lists and high level products is directly correlated with the stability of the spacecraft during the exposure.

Starting from an attitude data time series as created by **atthkgen** and a given exposure in the current ODF (pointed at by the environment variable `SAS_ODF`) **attfilter** carries out the following operations in sequential order:

[1] Please note that this statement is currently not correct in the case of **rgsangles** which only implements a first-order treatment of the exact aspect drift correction equations. This inadequacy will be removed in a future version.

1. Inquire the start and end time of the exposure specified via the parameter `instexpid`
2. Disregard the attitude data (specified via parameter `attset`) which lie outside the exposure time window
3. Compute the *median* spacecraft attitude within the exposure time window. In default of a mathematically rigorous definition of this quantity the median attitude is calculated as the composition of the individual medians of:
   - Right Ascension (J2000) of star tracker viewing direction
   - Declination (J2000) of star tracker viewing direction
   - Astronomical position angle of spacecraft
4. Generate a GTI table with the task **tabgtigen** under the control of a filtering expression which involves the previously computed median spacecraft attitude values and a user-specified set of tolerance angles (see parameter `tolangles`) $(\alpha_1, \alpha_2, \ldots)$. There are two ways to choose the filtering expression: The user can either give the full expression himself via the parameter `expression` in conjunction with setting `filtertype=user` or choose one of two predefined filters (in the following $\vec{P}_{med}$ designates the median and $\vec{P}(t)$ the actual spacecraft pointing direction at time t expressed as unit vectors in the earth-centered J2000 sky reference system):
   (a) cone (`filtertype=cone`):
   $$\arccos(\vec{P}(t) \cdot \vec{P}_{med}) \leq \alpha_1 \tag{1}$$
   This equation describes a cone with symmetry axis $\vec{P}_{med}$ and half-opening angle α_1.
   (b) pyramid (`filtertype=pyramid`):
   $$\begin{aligned} \left| \left(A_{med} \cdot (\vec{P}_{med} - \vec{P}(t)) \right)_y \right| &\leq \alpha_1 \\ \left| \left(A_{med} \cdot (\vec{P}_{med} - \vec{P}(t)) \right)_z \right| &\leq \alpha_2 \end{aligned} \tag{2}$$
   where A_{med} stands for the direction cosine matrix corresponding to the previously computed median spacecraft attitude and $\vec{v}_y$ and $\vec{v}_z$ designate the y and z components of a vector v. The combination of the two equations describes a pyramid with a rectangular base subtending the two half-opening angles α_1 and α_2. This base rectangle is aligned with the spacecraft y and z axes which in turn are aligned with the RGS cross-dispersion and dispersion direction respectively.
5. Add the median spacecraft attitude values to the new GTI table as attributes `MEDI_RA`, `MEDI_DEC`, and `MEDI_APA`.

The task's main output is a new GTI table in a new or previously existing data set suitable for direct event list filtering.

4 Examples

The following is a short list of typical task invocations:

- `attfilter instexpid=PNU003`
  Generate attitude GTI table (with default name) from the unscheduled PN exposure 003 in the current ODF from cone-type filtering expression (with default tolerance angle).
- `attfilter instexpid=PNU003 tolangles="0.5*#ARCMIN"`
  Same as previous example but set the cone half-opening angle to 0.5 arcmin.
- `attfilter instexpid=PNU003 tolangles="0.5*#ARCMIN" gtitable=gti.ds:MYGTI`
  Same as previous example but the resulting GTI table gets the name `gti.ds:MYGTI`.
- `attfilter instexpid=PNU003 filtertype=user expression="abs(%RA%-%RA_MED%)<%TOL_1% && abs(%DEC%-%DEC_MED%)<%TOL_2% && abs(%PA%-%PA_MED%)<%TOL_3%"`
  Same as first example but the selection expression is given explicitly. It selects periods where the Right Ascension/Declination of the star tracker viewing direction and the position angle independently from each other did not deviate from their median values by more than given tolerance limits (see also description of parameters `expression`, and `tolangles`).

5 Parameters

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

Parameter	Mand	Type	Default	Constraints
instexpid	yes	string	R1U571	six-characters long

A six-character string which must uniquely identify one exposure in the current ODF pointed at by the environment variable `SAS_ODF`. The first two characters designate an instrument (`M1`, `M2`, `PN`, `R1`, `R2`, `OM`), the third character must be `S` or `U` for the schedule status of the exposure and the last three characters are the zero-padded exposure number within the ODF.

attset	no	data set	atthk.dat	must exist

The name of the observation-wide attitude time series data set created by **atthkgen**.

timecol	no	string	TIME	name of existing `D`-type column in `attset`

The name of the column in the attitude data set containing the time tags – passed to **tabgtigen** in parameter `timecolumn`.

racol	no	string	AHFRA	name of existing `D`-type column in `attset`

The name of the column in the attitude data set containing the Right Ascension values of the star tracker viewing direction.

deccol	no	string	AHFDEC	name of existing `D`-type column in `attset`

The name of the column in the attitude data set containing the Declination values of the star tracker viewing direction.

apacol	no	string	AHFPA	name of existing `D`-type column in `attset`

The name of the column in the attitude data set containing the astronomical position angle values.

gtitable	no	table	attgti.ds:STDGTI	valid table identifier

The name of the resulting output GTI table - can be the name of an already existing table (which will get overwritten) or the name of a new one in an existing or new data set.

filtertype	no	filter type selector	cone	cone|pyramid|user

A selection switch which determines the type of selection expression that the attitude time series is filtered with. `cone` and `pyramid` select the fixed cone- and pyramid filters (see above) respectively. The value `user` allows the specification of the expression directly via the parameter `expression`.

expression	no	attitude data filtering expression		**selectlib**-compliant expression

The expression that is to be used to perform the attitude data filtering in case `filtertype=user`. Before the expression is passed to **selectlib** the following substitutions are carried out:

substring	replaced by
`%RA%`	value of parameter `racol`
`%DEC%`	value of parameter `deccol`
`%APA%`	value of parameter `apacol`
`%RA_MED%`	computed median of Right Ascension of star tracker viewing direction
`%DEC_MED%`	computed median of Declination of star tracker viewing direction
`%APA_MED%`	computed median of spacecraft position angle
`%TOL_n%`	nth ($n >= 1$) element in list of angles given by parameter `tolangles`

For example, the fixed cone-type filtering expression reads:
`skyvector(%RA%*#RAD, %DEC%*#RAD) in cone(skyvector(%RA_MED%, %DEC_MED%), %TOL_1%)`

tolangles	no	list of tolerance angles	`#ARCMIN`	**selectlib**-compliant numerical expressions

A list of **selectlib**-compliant expressions which must evaluate to a list of angle values in radians. Those values shall replace the symbolic constants `%TOL_1%`, `%TOL_2%`, ..., in the expression given in `expression` before this is passed to **selectlib** for performing the actual data filtering. For the fixed cone- and pyramid filter only the first and first two values shall be used respectively.

mingtisize	no	minimum size [s] of each GTI	10	> 0

Any found good time interval shorter than this limit shall not be considered, i.e., not be written to the resulting output GTI table `gtiset`.

maxfracshort	no	maximum allowed fraction of GTIs shorter than `mingtisize`	0.1	0 <=`maxfracshort`< 1

The ratio of the sum of all too short GTIs (according to the minimum length given by `mingtisize`) and the total exposure time must not exceed this number. If it does a warning is issued and the user is prompted to review the specified tolerance limits (see `tolangles`).

6 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

NotYetImplemented *(error)*
The pyramid filter is not implemented yet.

MaxFracShortExceeded *(warning)*
There appears to be an excessive number of very short GTIs (see parameters `mingtisize`, `maxfracshort`) - review the specified tolerance limits.
corrective action: none

Except for this, no errors or warnings are generated by the task directly. Only a subset of possible warnings and errors from the used packages, **oal**, **dal**, **selectlib**, and **tabgtigen** can occur.

7 Input Files

1. Attitude data time series as generated by **atthkgen**.

8 Output Files

1. Standard GTI table for event list filtering with additional attributes `MEDI_RA`, `MEDI_DEC`, and `MEDI_APA`.

9 Algorithm

```
+ select exposure and obtain exposure boundaries
+ cut out relevant part of attitude time series
+ calculate median values (RA/DEC/APA) on restricted set
+ compose selection expression using computed median values
+ invoke tabgtigen
+ add median attitude values to new GTI table
```

10 Comments

- The pyramid filter is not implemented yet as is requires functionality beyond **selectlib**'s current capabilities (matrix-algebra). At present the functionality offered by the cone-filter is deemed sufficient even for RGS.

References