merge

August 15, 2005

Abstract

This task merges EPIC event lists or additional files (attitude, orbit) from two exposures (even from different observations and instruments), pointing in the same or an adjacent direction. Sky coordinates are (optionally) adjusted for attitude errors and then reprojected to a common reference point. The output files can be used by **evselect** and the higher level detection and time analysis tasks.

1 Instruments/Modes

Instrument	Mode
EPIC PN	IMAGING
EPIC MOS	IMAGING

2 Use

pipeline processing	no
interactive analysis	yes

3 Description

Two files from two exposures (even from different observations or instruments) are taken as input. These may be EPIC event lists or two other additional files (attitude files, orbit files etc [see comments]). The files are checked via their extension names (`EVENTS`, `ATTHK`, `ORBIT`) for their type, and depending on the type, certain attributes are checked to see whether the files are compatible with each other. In the attitude and orbit cases, any files can be merged together (so long as they are both attitude or both orbit files), whereas in the events case, some care should be taken. For instance event files from different modes should not be merged, though perhaps event files from different instruments can (see comments). Warnings are given when the event files are deemed not entirely compatible (i.e. their `INSTRUME` or `FILTER` keywords are different). Here it is up to the user to interpret the output files sensibly.

Also, in the event files case, the two pointings need to be close to each other; the accuracy of the reprojection degrades with the offset between the two pointings, and warnings will be given when this offset becomes significantly large. Only if the input files pass all the checks does the merging proceed and an output file (event list, attitude file, orbit file) is produced. The individual blocks (e.g. `EVENTS`) are

merged in time order, as are the other relevant extensions (e.g. EXPOSUnn, STDGTI, etc [see comments]). In the event files case, the sky coordinates are deprojected and reprojected again onto a common sky position (given either by the user, via the parameters withradec, ra and dec, or as, by default, the mean of the two input pointings), and new WCS attributes are calculated (the size of the WCS 'image' is given by the parameter imagesize). It is possible also to adjust the individual event file sky coordinates prior to merging. This is useful when one sees offsets between sources in two datasets. Changes to RA, Dec and position angle can be given for each of the input event files (see examples).

Given here is a summary of the current conditions whereby event files (or parts thereof [blocks/columns etc]) are or are not merged. In each condition, the necessary warning/error messages are given.

Condition	Action
Different INSTRUME	continue (warning)
Different INSTRUME	EXPOSUnn extensions not merged (warning)
Different INSTRUME	STDGTI* extensions not merged (warning)
Different FILTER	continue (warning)
Different DATAMODE	stop (error)
No block (extension) in one/both file(s)	extensions not merged (warning)
No column in one/both extension(s)	columns not merged (warning)
TIME column missing in one/both file(s)	extensions merged in input order (warning)
No X/Y columns in one/both extension(s)	X/Y columns not reprojected (warning)

If present, the following event file columns will be merged: TIME, RAWX, RAWY, DETX, DETY, X, Y, PHA, PI, FLAG, PATTERN, PAT_ID, PAT_SEQ, PAY_TYP, PAT_IND, PAT_ORG, CCDNR, WEIGHT. Up to 12 additional columns may be specified by command line parameter.

The output files can be used by **evselect** and the higher level detection and time analysis tasks.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
set1	yes	string		
first input file				
set2	yes	string		
second input file				
outset	yes	string		
output file				
withradec	no	boolean	N	Y/N
input user-defined RA/Dec (otherwise mean used)				
ra	no	real	0.0	0−360
celestial RA coordinate of new reference point (if withradec=Y) (deg)				
dec	no	real	0.0	-90−+90
celestial Dec coordinate of new reference point (if withradec=Y) (deg)				
imagesize	no	real	0.36	>0

half-size of final merged image (deg) (see comments)

withset1adjustpos	no	boolean	N	Y/N

Adjust sky positions of set 1 events before merge

set1deltara	no	real	0.0	-5−+5

Change in RA (set 1) (deg) (if withset1adjustpos=Y)

set1deltadec	no	real	0.0	-5−+5

Change in Dec (set 1) (deg) (if withset1adjustpos=Y)

set1deltaposangle	no	real	0.0	-180−+180

Change in position angle (set 1) (deg) (if withset1adjustpos=Y)

withset2adjustpos	no	boolean	N	Y/N

Adjust sky positions of set 2 events before merge

set2deltara	no	real	0.0	-5−+5

Change in RA (set 2) (deg) (if withset2adjustpos=Y)

set2deltadec	no	real	0.0	-5−+5

Change in Dec (set 2) (deg) (if withset2adjustpos=Y)

set2deltaposangle	no	real	0.0	-180−+180

Change in position angle (set 2) (deg) (if withset2adjustpos=Y)

columns	no	string		

optional event list columns to be merged (up to 12 column names may be specified)

5 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.

filesNonCompatible *(error)*
Input files are non-compatible (file type, `DATAMODE`)

filesNonCompatible *(warning)*
Input files not entirely compatible (`INSTRUME`, `FILTER`)
corrective action: Input files are merged - care should be taken as to subsequent use

noExposureMerge *(warning)*
Input files are from different instruments - EXPOSURE extensions not merged
corrective action: Different instrument Exposure extensions not merged

noGTIMerge *(warning)*
Input files are from different instruments - GTI extensions not merged
corrective action: Different instrument GTI extensions not merged

largePointingOffset *(warning)*
Pointings are offset by a significantly large amount
corrective action: Reprojection is performed - care should be taken as to subsequent use

noExtension *(warning)*
extension does not exist in one or both files - not merging
corrective action: Particular extension is not merged into output file

noTimeColumn *(warning)*
TIME column missing in one file - cannot establish order
corrective action: Files are merged in the user-input order

noColumn *(warning)*
Column 'Column name' missing in one file - not merging
corrective action: Particular column is not merged into output file

noXYColumns *(warning)*
`X` and/or `Y` columns do not exist in one or both input files - no reprojecting
corrective action: Coordinate reprojection is not performed

fileTimeOverlap *(warning)*
Files overlap in time - some TIME keywords cannot be correctly calculated
corrective action: Calculation of some keywords not performed - ONTIME, LIVETIME etc

tooManyColumns *(warning)*
Too many columns given on command line
corrective action: Only first 12 user-specified columns will be copied

6 Input Files

One of the following: Either

1. Two **evlistcomb** EPIC output event files, or
2. Two **atthkgen** output files, or
3. Two **orbit** output files

Keywords read are (depending on input files): `TELESCOP`, `INSTRUME`, `FILTER`, `DATAMODE`, `TCRVL`, `TCDLT`, `TCRPX`.

7 Output Files

1. Merged file of the two input files. In the events case, the `X`, `Y` sky coordinates are reprojected to a new common reference point, and new WCS attributes are calculated.

Extra/new keywords written (depending on input files): `DATE-END`, `EQUINOX`, `RADECSYS`, `TCRVL`, `TCDLT`, `TCRPX`, `TCTYP`, `TLMIN`, `TLMAX`, `TDMIN`, `TDMAX`, `TCUNI`.

8 Algorithm

```
subroutine merge

 * get file types, and depending thereupon, call particular
     setup subroutine
 * depending on type, check for file consistency. Get time-ordering of
     input files
 * merge files and main extensions, using common merge subroutine, merge
     individual columns only when they exist in both datasets.
   * if type=events, call routines to (optionally) correct individual event
       file coordinates for small changes in RA, Dec and PA, then reproject
       sky positions onto single reference point on sky and calculate new
       WCS parameters.
   * if type=events, merge EXPOSURE and GTI extensions, using common merge
       subroutine, again checking for availability of extensions and columns
 * change header attributes where necessary, add history

end subroutine merge
```

9 Comments

- The task is now able to correct both individual input event files for small errors in attitude, prior to merging. Very thorough testing of this feature has not yet been performed. Position angle is measured clockwise on the sky.
- As this task is in its initial stages, care should be taken in using any output. Cases have been found whereby new output file attributes need to be calculated on the basis of input file attributes, and no doubt, these cases will continue to crop up.
- Input is welcome as regards whether it is sensible to merge certain types of files, with certain keyword setups. It would be nice for the task to be as unrestricted as possible, though in many cases, care will be needed as regards any subsequent use of a particular merged file.
- In the event file merging, the `BADPIX` extensions are not merged.
- It may be that the default `imagesize` may change, as merged images are likely to cover a large area of the sky than single event file images.
- When merging two files (C, A say) from different exposures, the two files will be automatically ordered so that they are merged in time order (AC). If one then wants to merge a third file (B) to the first two, this third file data being from a time in-between the first two, then problems *may* exist with subsequent tasks performed on the resultant merged file (ACB) as the data will not be time sorted. It is advised therefore to merge all data in time order (i.e. first A with B, then AB with C).
- It is advisable also, because of the large file sizes involved, the time-consuming nature of the reprojections and the fact, in merging e.g. four event files together, that three **merge** runs are necessary (A+B, AB+C, ABC+D, done preferably, remember, in time order, and not for instance in file size order), that the event files are first filtered to only the good events one is interested in.
- See future developments.

10 Future developments

- In addition to the comments, many questions exist regarding merging files over from different exposures, and the handling of EXPOSURE, GTI and BADPIX extensions.
- In merging event files from different EPIC instruments (i.e. MOS and pn), the event attribute columns should not be merged, as different instruments assign different meanings to the same bits. Merging across different instruments should be done after good events have been selected (this is related also to the point above in the comments).

11 Examples

- *merge set1=ev1.fits set2=ev2.fits outset=evout.fits* (Merging two event files, reprojecting X/Y coordinates to mean reference point)
- *merge set1=ev1.fits set2=ev2.fits outset=evout.fits withradec=Y ra=1.1 dec=-0.7* (Merging two event files, reprojecting X/Y coordinates to user reference point)
- *merge set1=ev1.fits set2=ev2.fits outset=evout.fits withset1adjustpos=Y set1deltara=0.012 set1deltadec=-0.003 set1deltaposangle=0.001* (Merging two event files, reprojecting X/Y coordinates to mean reference point - set1's events are corrected for small attitude corrections prior to merging)
- *merge set1=att1.fits set2=att2.fits outset=attout.fits* (Merging two attitude files, i.e. atthkgen output files)
- *merge set1=orb1.fits set2=orb2.fits outset=orbout.fits* Merging two orbit files, i.e. orbit output files)

Note: it is possible in many cases to treat the output files as ordinary (non-merged) files. For example, creation of an exposure map is possible for merged data: First **merge** the relevant event files and associated atthkgen output files, then form a sky image (via **evselect**) from the merged event file, then run **eexpmap** as normal using this image and the merged event and attitude files.

Just to reiterate, do take care with any merged output. This task is still under development.

References