movecalc

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Abstract

CALCulate event coordinates in a MOVing reference frame

1 Instruments/Modes

EPIC MOS : all imaging modes
EPIC PN : all imaging modes
OM : Fast

2 Use

pipeline processing	no
interactive analysis	yes

3 Description

movecalc and the related task `iauephem` are intended to facilitate the spatial analysis of observation data from moving objects such as comets or other solar system bodies. In still sky images generated from aspect corrected `X/Y` coordinates the spatial distribution of events from these objects can be very complex and depends on the projection of the object's track onto the image plane. This makes spatial event selection very hard of even impossible in cases where the object is too faint to clearly stand out against the X-ray background.

movecalc takes an event table with aspect corrected `X/Y` coordinate columns (as generated by task **attcalc**) and adds two new columns `X_MOV/Y_MOV` (different names can be specified via parameters `xmovcol/ymovcol`) containing the corresponding coordinates in a reference frame that is centered on the moving object at all times. This requires a second input table which defines the track of the object as a function of time. The table is created with the task `iauephem` and passed to **movecalc** via the parameter `objtrack`. **movecalc** shall interpolate the object tracking data in time on an event by event basis. This requires access to the event arrival times in a column `TIME` by default.

The new `X_MOV/Y_MOV` coordinate system is characterized by the following properties:

- The origin coincides with the center of the moving object at all times.
- The orientation is that of the underlying X/Y system, i.e. +X_MOV points east-wards and +Y_MOV to the celestial North pole.
- Each coordinate pair defines a point in a plane that is tangent to the celestial sphere (standard zenithal gnomic projection). The tangent point is given by the center of the moving object at all times.

Please note: Geocentric parallax shifts are taken into account. This refers to the fact that the apparent direction from the satellite to the object does in general not coincide with its geocentric position vector. The effect is the bigger the closer the object is.

3.1 FITS/WCS considerations

Ordinary X/Y sky images have a FITS representation that adheres to the World Coordinate System conventions specified in [1]. In practice this means that the conversion from tangent plane image coordinates (X/Y) to Right Ascension/Declination of the mean geocentric equatorial reference frame and vice versa is uniquely given by the following set of column attributes:

attribute name	meaning	X/Y system	X_MOV/Y_MOV system
TCTYPn	type of projection	RA--TAN/DEC--TAN	RA--TAN/DEC--TAN
TCRVLn	R.A./Dec of tangent point	$ra_{\rm ref}/dec_{\rm ref}$	0/0
TCRPXn	image coordinates of tangent point	$x_{\rm ref}/y_{\rm ref}$	0/0
TCDLTn	coordinate increment at tangent point	$\Delta x/\Delta y$	$\Delta x/\Delta y$

In the X_MOV/Y_MOV system the tangent point is moving with time. In the absence of a true FITS/WCS standard for this situation the point is given the fixed equatorial coordinate (0/0). This allows FITS image viewers like Ds9 to display 'pseudo' sky coordinates for each image pixel which shall at least be useful to estimate extents of structures in the X_MOV/Y_MOV image. Please note that the coordinate increment in both systems is the same.

3.2 Usage examples

1. Add columns X_MOV/Y_MOV to table EVENTS in data set comet.ds. The track of the object is defined in table comet_track.ds:

```
movecalc table=comet.ds:EVENTS objtrack=comet_track.ds
```

2. Add columns X_VAR/Y_VAR to table EV in data set saturn.ds. The track of the object is defined in table saturn_track.ds:

```
movecalc table=saturn.ds:EV objtrack=saturn_track.ds xmovcol=X_VAR ymovcol=Y_VAR
```

4 Parameters

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

Parameter	Mand	Type	Default	Constraints

table	yes	table name		name of existing table

A table specifier which must point to an existing table in a data set that contains the columns specified via parameters `xcol/ycol`. On successful exit the two columns named via parameters `xmovcol/ymovcol` will have been added to the table

.

objtrack	yes	data set	`track.ds`	name of existing data set

Name of a data set created by task `iauephem` which defines the position of the moving object as a function of time.

xcol	no	column name	X	name of existing column in table `table`

The name of the column containing tangent plane projected X-coordinates of the events.

ycol	no	column name	Y	name of existing column in table `table`

The name of the column containing tangent plane projected Y-coordinates of the events.

timecol	no	column name	TIME	name of existing column in table `table`

The name of the column containing event arrival time tags.

xmovcol	no	column name	X_MOV	valid column name

Name of the column to be added to the input table `table` containing X-coordinates of the events in the moving reference frame; must be different from name of corresponding input column `xcol`.

ymovcol	no	column name	Y_MOV	valid column name

Name of the column to be added to the input table `table` containing Y-coordinates of the events in the moving reference frame; must be different from name of corresponding input column `ycol`.

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.

DalError *(error)*
All errors from the **dal** resulting from an attempt to access a non-existing data set, table, column, or attribute. This will usually hint at one or more invalid task parameter values.

NoOrPartialTemporalOverlap *(error)*
The time span covered by the object track data set `objtrack` does not or only partially overlap with the exposure data in the input table `table`. This will usually hint at invalid time boundaries that have been specified in running task `iauephem`.

6 Input Files

1. event list with sky image columns `xcol`/`ycol` generated by **attcalc**
2. data set generated by task `iauephem` defining the position of the moving object as a function of time. Please note that `iauephem` does not have to be used to prepare the input but any tools which generates a data set with a single binary table (with any name) and the folling minimal column structure:

column name	meaning	type	units
MJD	modified Julian Day number	real64	d
`RA`	apparent geocentric Right Ascension	real32	deg
`DEC`	apparent geocentric Declination	real32	deg
`DELTA`	distance to center of earth	real32	AU

7 Output Files

1. input event list with two columns `xmovcol`/`ymovcol` added

8 Comments

XMM-Newton is likely to observe various comets and other solar-system objects as part of the AO2 program. The proposed task shall be a valuable tool in the spatial analysis of the observation data especially since the functionality does not seem to be readily available elsewhere.

9 Future developments

It is anticipated that more functionality shall be added to this package in the future. The proposed task **movecalc** is an important part in the analysis of data from moving objects but can only address spatial aspects. Another related task might be `regionunmove` to convert a spatial X_MOV/Y_MOV region selection into X/Y space.

References

[1] E. W. Greisen and M. Calabretta. Representation of Celestial Coordinates in FITS. *Astron. Astrophys.*, 1996. Found at the URL: `ftp://fits.cv.nrao.edu/fits/documents/wcs/wcs.all.ps`.