eregionanalyse

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Abstract

A routine to analyse regions in an input image and return information about it in a set of parameters

1 Instruments/Modes

Instrument	Mode
EPIC	IMAGING

2 Use

pipeline processing	no
interactive analysis	yes

3 Description

This task is designed to analyse a region within an XMM image. It calculates values such as a source centroid, optimum extraction radius, source counts and count rate etc. All values are written to standard output where they may be accessed by a calling script. The centroid, source counts and optimum radius are also returned in output parameters where they may be picked up by a calling task. A summary of the output quantities is given in Table 1.

3.1 Input

3.1.1 Source image

The source image may be input in detector or sky (X/Y) coordinates. The task expects to find astrometry keywords in a certain part of the primary header and will exit with an error if the keywords are not found. Standard images produced by evselect and xmmselect and the pipeline will process ok. The background spline maps produced by the pipeline source detection chain and the exposure maps produced by eexpmap need to be pre-processed before they can be used within eregionanalyse (see section 8).

Table 1: **Output quantities**

Value	Units	Output Parameter
Source counts	counts	srccnts
Counts per image pixel	counts/pixel	-
Exposure time	seconds	-
X centroid	det or sky pixels	xcentroid
Y centroid	det or sky pixels	ycentroid
optimum radius	arcsecs and det/sky pixels	optradius
encircled energy factor	-	-
Total source counts[a]	counts	-
Total source count rate	counts/s	-

[a] The background subtracted source counts corrected for the encircled energy fraction.

3.1.2 Background

There are three possible ways of entering the background.

1. From a background region within the source image via the `backexp` parameter. In this case the task normalises for the different source and background region areas. NB: This normalisation does not take account of bad pixels, bad columns or chip gaps.

2. From a background image in which case the background is taken from the source region within the image specified in the `bkgimageset` parameter.

3. As a single value entered in counts per second via the `bckval` parameter.

3.1.3 Exposure

By default the exposure time used for converting counts to count rate is read from the EXPOSURE keyword in the header of the source image. An exposure map may be introduced by the `exposuremap` parameter in which case the exposure time is taken as the value at the central pixel of the source region within the exposure map.

3.1.4 Source and background regions

Spatial regions may be entered in detector, sky (X/Y) or celestial (RA, DEC, FK4 2000) coordinates. If the coordinates of the region are not the same as those of the image, e.g. a sky pixel region on a detector coordinate image, then the task will still function but will run more quite slowly. An error will result if the spatial region is not within the image. Any shape conforming to the **selectlib** rules may be used but see section 3.2.7

3.2 Output

3.2.1 Input region centre

The centre of the input region. If the image is in image coordinates then the centre is returned as an RA, DEC position, if the image is in detector coords the centre is returned in detector coordinates.

3.2.2 Source sounts

Simply the number of counts contained within the image pixels within the source region.

3.2.3 Source counts per image pixel

The total source counts divided by the number of image pixels in the source region.

3.2.4 Exposure time

Either the total exposure time of the image or the value of the exposure map at the centre of the source region.

3.2.5 Centroid

The centre of the counts distribution within the source region in the same units as the image, i.e. detector or sky pixels.

3.2.6 Optimum radius

The radius of a circular extraction region which gives the maximum signal to noise ratio calculated from the source counts, the encircled energy function and the background. The EXTENDED mode PSF is used to calculate the encircled energy function. This is output in arcseconds and in the units of the image (i.e. detector or sky pixels). In the output parameter `optradius` it is stored in image units.

3.2.7 Encircled energy factor

The fraction of counts contained within the source region assuming a point source located at the centre of the region. The EXTENDED mode (King profile) PSF is used to calculate the fraction assuming a fixed photon energy of 1.5 keV. This is currently only implemented for circular source regions, other shapes will give the wrong factor.

3.2.8 Background subtracted source counts

The total counts emitted by the source, found from the counts in the source region minus the contribution from the background divided by the encircled energy fraction.

$$counts = (S - B \times A_S/A_B)/EEF \quad (1)$$

where S is the counts within the source region, B is the total background counts and A_S, A_B are the area of the source and background regions respectively.

The background is simply scaled by the respective box areas; no vignetting correction of any sort is made. The error is calculated from photon statistics as:

$$error = \sqrt{S + B \times (A_S/B_S)^2} \quad (2)$$

NB: This is only reliable for circular source regions, see section 3.2.7

3.2.9 Background subtracted source count rate

The background subtracted source counts and error divided by the exposure time.

NB: This is only reliable for circular source regions, see section 3.2.7

3.3 Output format

The output format shown below is independent of the SAS_VERBOSITY setting. The strings shown may be searched for in a script and every effort will be made to keep them constant between versions of this task.

```
eregionanalyse:-  input region centre: 639 -769
 counts in source region: 380980
 src region cnts per pixel: 633.91
 exposure time: 56988
 xcentroid: 25855
 ycentroid: 25858
 optradius: 64 arcsecs 1280 image units
 encircled energy correction: 0.920266
 Bckgnd subtracted source cnts: 393892 +/- 686.748
 Bckgnd subtracted source c/r: 6.91184 +/- 0.0120507
```

3.3.1 Analyse an on-axis source

```
eregionanalyse imageset=emosimagedet.ds srcexp="(DETX,DETY) in CIRCLE(639,-769,1200)"
backexp="(DETX,DETY) in CIRCLE(11400,-700,1200)"
```

This will set the parameters, `xcentroid` and `ycentroid`, to be the centre of the counts distribution within the source box; the optimum radius from the source and background count distribution and the number of counts in the source box. The screen output will be like that shown in section 3.3.

3.3.2 Use a fixed background value

```
eregionanalyse imageset=epnimage.ds srcexp="(X,Y) in CIRCLE(25920,24800,1200)"
backval=0.1
```

Analyses the source region using a background value of 0.1 counts per arcsecond squared.

3.3.3 Use a background image

```
eregionanalyse imageset=emosimage.ds srcexp="(RA,DEC) in CIRCLE(65.3281,-76.0014,0.01666)"
bkgimageset=emosback.ds
```

Finds the source counts from a one arcminute circle about the celestial position (65.3281,-76.0014) and uses the same area in the background image to find the background counts.

3.3.4 Use an exposure map

```
eregionanalyse imageset=emosimage.ds srcexp="(RA,DEC) in CIRCLE(65.3281,-76.0014,0.01666)"
bkgimageset=emosback.ds exposuremap=emosexpos.ds
```

Calculates the background subtracted source count rate using an exposure value extracted from the centre of the source region in the exposure map.

4 Parameters

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

Parameter	Mand	Type	Default	Constraints
imageset	yes	string	image	

The name of the input image.

srcexp	yes	string		

Expression for extracting the source events.

backexp	no	string	NotSet	

Expression for extracting the background events. If not set the background value is taken from the parameter backval.

bkgimageset	no	string	NotSet	

The name of the background image

exposuremap	no	string	NotSet	

The name of the exposure map

backval	no	double	0.0	

The background value in cnts per square arcsecond. This value is used if a backexp expression has not been set, otherwise the parameter is ignored.

xcentroid	no	double		

Output parameter that contains the X coordinate centroid. This will be in the units of the input image, e.g. sky pixels, detector pixels or degrees.

ycentroid	no	double		

Output parameter that contains the Y coordinate centroid. In the units of the input image.

optradius	no	double		

Output parameter that contains the optimum extraction radius in the units of the input image (sky

pixels, detector pixels or degrees).

srccnts	no	double		

Output parameter that contains the total src (+backgnd) counts within the source region.

status	no	boolean		

Output parameter. This is set to false if the input image was from a Timing or Burst mode observation which **e**regionanalyse can not yet handle. Otherwise it is set true.

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.

InvalidExpression *(error)*
The input expression for this spatial region was not valid.

InvalidRegion *(error)*
The centre of the source or background region lies outside of the image

invalidArraySize *(error)*
The image is not two dimensional.

InvalidWCSType *(error)*
The image axes specified in the CTYPE1 and CTYPE2 keywords are not compatible.

UnknownModeString *(warning)*
If the spectrum contains an observing mode (in the keyword SUBMODE) which is not recognised then the software assumes that that the common PrimeFullWindow mode was in use. The mode is used to calculate certain calibration quantities.
corrective action:

NoInstrument *(warning)*
If the INSTRUME keyword is not set in the image header a warning is issued and the default of MOS-1 is taken. The instrument determines the PSF used and the position of the optical-axis.
corrective action:

InvalidPosWCSInfo *(warning)*
The REFerence keywords in the image header, e.g. REFXCRPX, REFXCRVL, REFXCDLT are incomplete. Defaults are chosen but there is likely to be a problem later.
corrective action:

6 Input Files

- an EPIC image produced by evselect or xmmselect or the pipeline.

- optionally an EPIC background image such as the spline maps produced by the epic source detection pipeline.
- optionally an exposure map.

The background spline maps from the pipeline and the exposure maps produced by the task **eexpmap** have headers which are incompatible with **eregionanalyse**. The simplest way of solving this problem is to replace their headers with that of the source image by using an ftool, e.g.:

```
farith srcimage.fits bkgimage.fits tempfile.fits "+"
farith tempfile.fits srcimage.fits newbackgndfile.fits "-"
```

which will produce a new file, newbackgndfile.fits, with the data component from the original background file, bkgimage.fits, and the header of the source image, srcimage.fits.

7 Output Files

8 Algorithm

8.1 Optimisation

```
SNRMAX=0

TOTAL_SRC_COUNTS = counts in the input image within the source region
                   corrected for the encircled energy fraction of the
                   source region

Loop TEST_RADIUS = 1 to 300 arcseconds

   EEF = calculate encircled energy fraction for this TEST_RADIUS
         using the PSF relevant for this Epic camera at the
         position of the source box for a photon energy of 1.5 keV

   SRC_COUNTS = TOTAL_SRC_COUNTS * EEF

   BGD_COUNTS = background counts per arcsec^2 * PI * TEST_RADIUS**2

   S/N ratio = SRC_COUNTS / sqrt(SRC_COUNTS + BGD_COUNTS)

   if (S/N ratio > SNRMAX) {
      SNRMAX = S/N ratio
   }

EndLoop
```

9 Comments

This task has been extensively tested against the count rates returned by the XMM pipeline source search and parameterisation tasks. The results are consistent apart from a small variation due to the EXTENDED mode PSF used here. The pipeline task **emldetect** uses the MEDIUM mode PSF.

References