Manual for "mosaic_weight" and its inputs

How to use the program and prepare input images

JEM–X technical note 14

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1 Introduction

The idea of the proposed changes is to lift the mosaic_weight program from an adhoc status to one of more general usage. On the other hand this imposes constraints on the input information, but in my opinion nothing difficult.

2 The "mosaic_weight" program

This program is based on algorithms written by Niels J. Westergaard and Niels Lund. This software takes account of the specifics of the JEMX instrument, such as vignetting effects due to its collimator and its mask structure. It calculates the weighted contribution of each pixel from each input sky images to be added in order to maximise the signa/noise ratio of each pixel in the combined mosaic image.
First, the user has to prepare the environment necessary to compile the program. At DSRI we use the following:

```
setenv ISDC_VERSION 5_2
setenv ISDC_ENV /t/jemx/isdc/isdc$ISDC_VERSION
setenv CFITSIO_INCLUDE_FILES .:$ISDC_ENV/templates
setenv CFITSIO_INC_DIR $ISDC_ENV/support-sw/cfitsio
setenv CFITSIO_LIB_DIR $ISDC_ENV/support-sw/cfitsio
setenv AUXL_REF_DIR $ISDC_ENV/share
setenv PATH $ISDC_ENV/bin:$PATH
setenv PFILES .:$ISDC_ENV/pfiles:$PFILES
setenv LD_LIBRARY_PATH $ISDC_ENV/lib:$LD_LIBRARY_PATH
setenv CC gcc
setenv CXX g++
```

Next, it is necessary to define where the produced fits files are going to be created ($PWD in the following):
setenv DAL_CURRENT_DIR $PWD
You may find a working version of the software at DSRI under

/r6/jemx/jerome/Mosaic/INSTALL

Besides the source code, it contains the file 'makeisdc1.in' that creates a makefile by using the following command:

$ISDC_ENV/bin/ac_stuff/configure –without-fortran90 –without-isdcroot

Then just type "make" to get the executable "mosaic_weight".
This program is written to use either Niels Lund's or Carl Budtz-Jorgensen's sky images as input (and eventually those created by Niels J. Westergaard's JEMX ISSW in OSA 3.1 at ISDC), though they do not have the same dimensions (NL: 255x255, CBJ: 262x262 or 525x525, and NJW: 200x200, respectively). The present package also includes .txt files containing the vignetting (or illumination) functions to be used with Niels or Carl's sky images respectively (correcting factors in cbj_vig.dat are also needed in the last case).
The input sky images fits files have to be listed with full path in a file as given in example by skymaps.lst included in the present package ; the number at the top of the file indicates to the program how many input fits files will be combined. The full (relative) path of the skymaps.lst (or another name of your own choice) must be given in the parameters file "mosaic_weight.par" as given in example. By default the output mosaic image is defined to be inside a diameter of 15 degrees, but if the input sky images angular separation is larger, the user may use the value "-1" in the parameters file. If sky coordinates are given for the center position of the mosaic a file "ranked_weights.txt" will be created that gives the ordered list of input images in respect to their relative weight at the given sky position.
The program produces two fits files named OBS_TIME_##.fits and MOSAIC_##.fits, where ## is the number of input sky images. OBS_TIME contains only one extension which is an image of the accumulated exposure times given in seconds. There are seven parameters to define the mosaic skymaps to create in the MOSAIC file, so it can have up to seven image extensions, respectively from [2] to [8], showing:

1. the weighted intensity (pixel values) map,
2. the effective exposure (exposure time*vignetting) map,

3. the weighted variance map,
4. a map over the sum of weights,
5. a map over the sum of weights square,
6. the source signal defined as the intensity divided by the effective exposure, and
7. the noise in each pixel defined as the sqrt(variance) divided by the effective exposure.

NB. The present version of the program cannot overwrite the output fits files, so the user needs to rename (or move or delete) them previous to a new run with the same number of input sky images.

2.1 Suggested changes

- The parameterfile to be changed to DAL (IRAF) format.
- The name of the output file to be defined by a parameter.
- It should no longer be required to put the number of files in the list of files.
- Files can be "commented out" in the file list by typing a '#' as the first character.

3 The input images

- The input skyimages must be in FITS format.
- The intensity information and the corresponding variance map must reside in the same FITS file.
- A FITS file may contain more images and "mosaic_weight" will include all that fulfil the selection set by the parameter values.

3.1 Keyword IMATYPE (required)

The FITS extension with intensity has keyword

IMATYPE = 'INTENSITY'

and the FITS extension with variance has keyword

IMATYPE = 'VARIANCE'

It is possible that the intensity map is not the only one. The skyimages by NL has two extra results:

IMATYPE = 'RESIDUAL'

(residual map, i.e. sources have been subtracted from shadowgram) and

IMATYPE = 'RESWSRCS'

"residual with sources".

3.2 Keyword VARIA_ID

In future use it could be useful to have more than a single pointing and energy interval stored in the FITS file. This keyword will tell which variance map to connect with the image array in question.
An example which shows how the INTENSITY and RESIDUAL maps are linked with the right VARIANCE map, would be:

ext#1
    IMATYPE = 'INTENSITY'
    VARIA_ID = 0
    E_MIN = 2.0
    E_MAX = 5.0
ext#2
    IMATYPE = 'VARIANCE'
    VARIA_ID = 0
    E_MIN = 2.0
    E_MAX = 5.0
ext#3
    IMATYPE = 'RESIDUAL'
    VARIA_ID = 0
    E_MIN = 2.0
    E_MAX = 5.0
ext#4
    IMATYPE = 'INTENSITY'
    VARIA_ID = 1
    E_MIN = 5.0
    E_MAX = 10.0
ext#5
    IMATYPE = 'VARIANCE'
    VARIA_ID = 1
    E_MIN = 5.0
    E_MAX = 10.0
ext#6
    IMATYPE = 'RESIDUAL'
    VARIA_ID = 1
    E_MIN = 5.0
    E_MAX = 10.0
ext#7
    IMATYPE = 'RESWSRCS'
    VARIA_ID = 1
    E_MIN = 5.0
    E_MAX = 10.0

This number could in principle also be used as a general reference number for the images.

3.3 Energy indication

The intensity and variance maps must be marked with energy keywords:

E_MIN and E_MAX (in keV)

Since NL and CBJ work in predefined energy intervals their "number" can be given with

ECODE (an integer between 0 and 4 (included))

This, however, does not replace the E_MIN and E_MAX keywords.
The energy selection is defined with parameters 'eminSelect' and 'emaxSelect'. "mosaic_weight" will only include images that fulfil eminSelect $\leq$ E_MIN *and* E_MAX $\leq$ emaxSelect.
Default values for eminSelect and emaxSelect would be 0 (zero) and 80 resp. In that case the file selection will determine the energy interval.
When it is certain that the ECODE keyword is included the energy selection can be based on that by setting the paramter 'useEcode' to 'y' and define the ecodeMin and ecodeMax parameters.

4 Auxiliary information

The exposure time (the observation time corrected for greyfilter and deadtime and bad-time-intervals) must be indicated with keyword 'EXPOSURE'.

The vignetting information must be contained in a FITS file and the DOL (Data Object Locator) must be given with keyword 'VIGNDOL'. Since the program can run on several systems only the filename (if necessary plus the extension number) should be given here. The absolute path must be given by a parameter.
Probably it should be decided that only a single vignetting array can be put in a file.

5 Parameters

fileList (string) Name of list with FITS files containing images

RAcenter (float) RA (J2000) of resulting image

DECcenter (float) DEC (J2000) of resulting image

diameter (float) Opening angle (deg) of resulting image

cdelt (float) Pixel size (deg) for resulting image

outfile (string) Name of output file

vignDir (string) Directory where to look for vignetting file

maxNumFiles (integer) Maximum number of files in include

eminSelect (float) Lower limit of individual E_MIN values

emaxSelect (float) Upper limit of individual E_MAX values

useEcode (boolean) Use ECODE when selecting energy ?

ecodeMin (integer) Lower limit of individual ECODE values

ecodeMax (integer) Upper limit of individual ECODE values

... (?) indications of what output is requested

6 Recommended keywords for the image FITS extensions

```
TELESCOP        INTEGRAL        / Telescope or mission name
ORIGIN          ISDC            / Origin of FITS file
INSTRUME        JMX1            / Instrument name
CREATOR         String          / Program that created this FITS file
CONFIGUR        String          / Software configuration
DATE            UTC_format      / FITS file creation date
REVOL           Integer         / Revolution number
SWID            String          / Science Window identifier
EXPOSURE        Real            / Mean exposure time over the detector plane
BSCALE          1               / Real value=value*BSCALE + BZERO
BZERO           0               / Offset applied to true pixel values
BUNIT           count/s         / Unit for pixel values
CTYPE1          String          / LONGPROJ where LONG can be RA, GLON, ELON and PROJ can be CAR, TAN or AIT
CRPIX1          Real            / Pixel at reference point
CRVAL1          Real            / LONG at the reference value
CUNIT1          deg             / Physical units of axis 1
CTYPE2          String          / LAT-PROJ where LAT can be DEC, GLAT, ELAT and PROJ can be CAR, TAN or AIT
CRPIX2          Real            / Pixel at reference point
CRVAL2          Real            / LAT at the reference value
CUNIT2          deg             / Physical units of axis 2
CD1_1           1.0             / Element (1,1) of coordinate transf. matrix (default 1)
CD1_2           0.0             / Element (1,2) of coordinate transf. matrix (default 0)
CD2_1           0.0             / Element (2,1) of coordinate transf. matrix (default 0)
CD2_2           1.0             / Element (2,2) of coordinate transf. matrix (default 1)
LONGPOLE        180             / Longitude in the native coord. system of the std system's N pole
LATPOLE         0               / Latitude in the native coord. system of the std system's N pole
RADECSYS        FK5             / Stellar reference frame
EQUINOX         2000.0          / Coordinate system equinox
HDUCLASS        OGIP            / Format conforms mostly to OGIP standards
HDUDOC          'ISDC-JEMX ADD' / Document in which the format is defined
HDUVERS         '3.0'           / Version of format
HDUCLAS1        IMAGE           / Sky Image
EVNTYPES        Integer         / Code for event types (0:FULL, 1:REST, -1:both)
E_MIN           Real            / [keV] Lower energy limit
E_MAX           Real            / [keV] Upper energy limit
E_MEAN          Real            / [keV] Mean energy
IMATYPE         String          / Type of image
```