ESTIMATION OF SOURCE LOCATION IN THE CROSS CODING DIRECTION IN SSM CAMERAS

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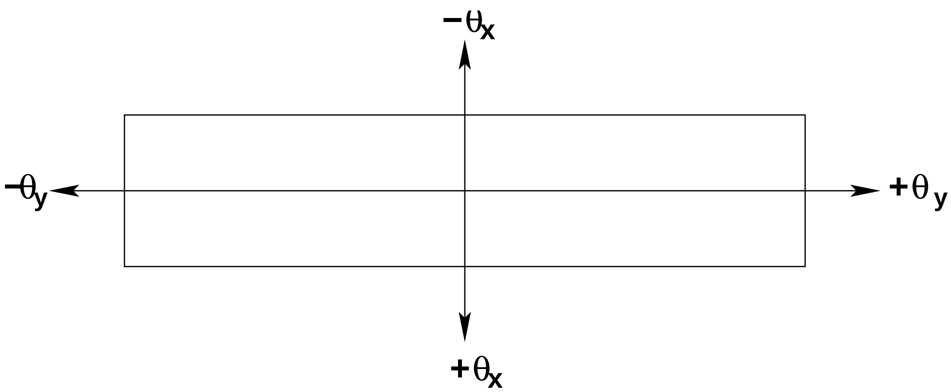
Aim : To find θy_1, θy_2 coordinates for the two slanted cameras. Given θx_1, θx_2 and time difference betrween the slanted cameras 1 and 2 respectively, where (θx_1, θx_2) and (θy_1, θy_2) are the camera coordinates along the X and Y directions as shown below,



SSM uses one dimensional coded mask. So only the X-coordinate can be calculated for each of the cameras. For the slanted cameras using the calculated values of the x-coordiantes and time difference between the slanted cameras, the Y-coordiantes for the respective cameras can be calculated.

The procedure :

Select the brightest source from the file uhuru.dat
In this case the following source is selected.

SOURCE DETAILS :

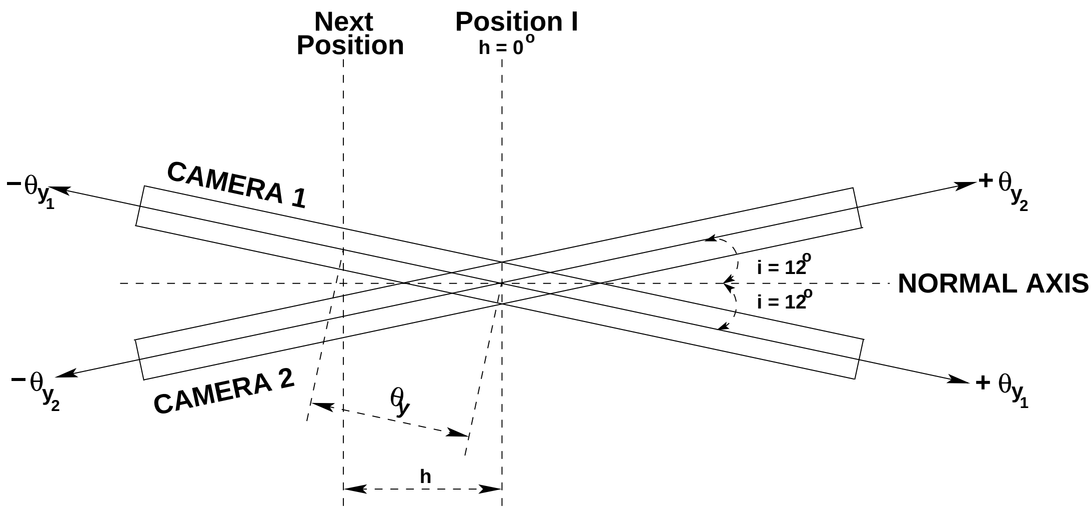
Source Name	: XB1455-31
RA.	: 223.83^o (-136.17^o for the projection used)
DEC	: -31.47^o
Counts	: 14000

The boom camera is rotated in such a way that the centres of the other two slanted cameras pass through the brightest source. That is considered as the starting point and the angular distance from the central scan line is moved left and right to cover the entire field of view of the camera. The time interval during which the source is seen in the fields of view of either of the two cameras is noted down.

Let the declination of the boom = 0.0^o i.e. Dec_b = 0.0^o and [Ra_b=Ra_source + 90^o]

Here Dec_b = 0.0^o because we know θx_1, θx_2 i.e. X-coordinate is known. To find θy_1 and θy_2 Ra_source is incremented in small steps from the current position I to +53.87^o and position I to -53.87^o to cover the entire fields of view along y-axis. Since both the slanted cameras are inclined at an angle of 12^o from the normal, increment in steps of "h" to a value greater than 53.87^o so that the source passes through the entire field of view of the camera.

Refer the program generate_y.c
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/generate_y.c)



Place the source in position I where difference in θx = 0 i.e. $\theta x_1 - \theta x_2 = 0$ i.e. at position [Ra_b=Ra_source + 90°]

"h" is incremented in steps of 10.774° ==> θy=h*cos(Dec_source)/cos(i)

where

i = 12°
Dec_source = -31.470°

The output of the file generate_y.c is stored in file "output_of_generate_y".

The file "output_of_generate_y" contains the following :
For each "h" value, the corresponding θx_1, θy_1, θx_2, θy_2 and time difference between the two slanted cameras, along with the predicted value of θy.

GNUPLOT:
The plots of θy_1 v/s θx_1 and θy_2 v/s θx_2 for the corresponding "h" steps are fitted using a ploynomial functions defined by:

$f(x) = a + bx + cx^2 + dx^3 + ex^4 + fx^5 +$ ....

The reduced chisquare value is noted for each one of them along with the fitted parameter values.

The above is done by creating various files for each set of data. For example :-
File gnu_theta_y[1.....13] contains θx_1 and θy_1 values for the corresponding "h" values. Similarly the file gnu_theta_y[1a......13a] contains θx_2 and θy_2 values for the corresponding "h" values.

In the function f(x), x is equated to zero (i.e. $\theta x_1 = 0$) and correponding θy_1 is found out. Similarly θx_2 is equated to zero and corresponding θy_2 is found out.
These values are tabulated

-- h v/s θy_1 [FILENAME : plot_h_thetay1]
-- h v/s θy_2 [FILENAME : plot_h_thetay2]

h v/s θy_1 and h v/s θy_2 are plotted. Their reduced chisquare value and the fitted parameters are noted and stored in a file named fit-values1.

Also the values of θx_1 and the corresponding step size in camera rotation (hereafter ϕ) for each set of "h" values are tabulated. These are stored in files called pi[1......13]. Similarly the values of θx_2 and the corresponding ϕ 's for each set of "h" values are tabulated. These are stored in files called pi[1a.....13a]. All of these are plotted and fitted with the polynomial function. By equating $\theta x_1 = 0$ and $\theta x_2 = 0$ the corresponding ϕ 's are found.

Difference in ϕ 's (i.e. $\Delta\phi$) = pi[1.....13] - pi[1a.....13a] are calculated

The curves listed are also plotted and fitted with a polynomial.

-- h v/s $\Delta\phi$ [FILENAME : plot_h_deltapi]
-- θy_1 v/s $\Delta\phi$ [FILENAME : plot_thetya1_deltapi]
-- θy_2 v/s $\Delta\phi$ [FILENAME : plot_thetay2_deltapi]
-- $\Delta\phi$ v/s h [FILENAME : plot_deltapi_h]
-- $\Delta\phi$ v/s θy_1 [FILENAME : plot_deltapi_thetay1]
-- $\Delta\phi$ v/s θy_2 [FILENAME : plot_deltapi_thetay2]

All these fitted parameters and their reduced chisquare values are stored in file called fit-values1.
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/fit-values1)

The procedure was repeated for a FICTITIOUS SOURCE, whose declination was assumed to be zero i.e. Dec_source = 0.0^o. For this purpose, a fictitious source was inserted into the Uhuru catalog file.

FICTITIOUS SOURCE DETAILS :

Source Name : FICTITIOU
RA : 250.0^o (-110.0^o for the projection used)
DEC : 0.0^o
Counts : 14001

Refer to the file uhuru-fict.dat
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/uhuru-fict.dat)

Refer the program fictitious-generate-y.c
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/fictious-generate-y.c)

The output of the code ficitious-generate-y.c is stored in file output-fict-source.

The file "output-fict-source" contains the following:
-- For each "h" value the corresponding θx_1, θy_1, θx_2, θy_2 and time difference between the two slanted cameras, along with the predicted value of θy are obtained.

GNUPLOT:
θy_1 v/s θx_1 and θy_2 v/s θx_2 for the corresponding "h" steps are plotted. The curve was fitted using a ploynomial function defined by:

$f(x) = a + bx + cx^2 + dx^3 + ex^4 + fx^5 +$ ....

The reduced chisquare value is noted for each one of them along with the fitted parameter values.

The above is done by creating various files for each set of data. For example :-
File fict-thetay[1.....11] contains θx_1 and θy_1 values for the corresponding "h" values.
Similarly the file fict-thetay[1a.....11a] contains θx_2 and θy_2 values for the corresponding "h" values.

In the function f(x) equating x to zero (i.e.$\theta x_1 = 0$) the corresponding θy_1 is found out. Similarly equating θx_2 to zero the corresponding θy_2 is found.

These values are tabulated
--- h v/s θy_1 [FILENAME : fict-h-thetay1]
--- h v/s θy_2 [FILENAME : fict-h-thetay2]

h v/s θy_1 and h v/s θy_2 are plotted. Their reduced chisquare value and the fitted parameters are noted and stored in a file named fict-fittedvalues.

The values of θx_1 and the corresponding step size in camera rotation (hereafter ϕ) for each set of "h" values are tabulated. These are stored in files called fict-phi[1......11]. Similarly the values of θx_2 and the corresponding ϕ 's for each set of "h" values are tabulated. These are stored in files called fict-phi[1a.....11a]. All of these are plotted and fitted with the polynomial function. By equating θx_1 to zero and θx_2 to zero the corresponding ϕ 's are found.

Differences in ϕ 's (i.e. $\Delta\phi$) = fict-phi[1.....11] - fict-phi[1a.....11a] are calculated.

Also the following files are also plotted and fitted :

--- h v/s $\Delta\phi$ [FILENAME : fict-h-deltapi]
--- θy_1 v/s $\Delta\phi$ [FILENAME : fict-thetay1-deltapi]
--- θy_2 v/s $\Delta\phi$ [FILENAME : fict-thetay2-deltapi]
--- $\Delta\phi$ v/s h [FILENAME : fict-deltapi-h]

--- $\Delta\phi$ v/s θy_1 [FILENAME : fict-deltapi-thetay1]
--- $\Delta\phi$ v/s θy_2 [FILENAME : fict-deltapi-thetay2]

All these fitted parameters and their reduced chisquare values are stored in file called fict-fittedvalues.
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/fict-fittedvalues)

NOTE :
The data for file fict-thetay6, fict-thetay6a, fict-thetay11 and fict-thetay11a are taken from the file output-fict-source.
(PATH : /misc/sat2/astrosat/SUSHILA/stage2/fictitious/output-fict-source)

The fit parameter of the two sources so obtained are comparable. If the parameters for a known source and a fictitious one match then one can conclude that for any given source, X-coordinates known, Y-coordinates can be obtained by following the procedure described to a higher level of accuracy which in-turn improves the resolution along the y-direction.

So using a polynomial function i.e.

$f(x) = a + b*x + c*x^2 + d*x^3 + e*x^4 + f*x^5 + ...$

One can calculate the other coordinate.

Given θx_1 and θx_2 as a function of time, to construct θy_1 and θy_2.
where θx_1 and θx_2 are the co-ordinates along the X-direction of the slanted cameras 1 and 2 respectively. Similarly, θy_1 and θy_2 are the co-ordinates along the Y-direction of the slanted cameras 1 and 2 [refer fig. 1].

The time span between the instance at which the source enters the field of view of slanted camera1 and leaves the field of view of slanted camera2 is known.

-- Then plot θx 's v/s corresponding ϕ 's
-- Fit this curve using a proper function i.e. define a function $f(\theta x) = \phi$
-- From the fitted parameter values, respective ϕ's are determined by equating θx_1 and θx_2 to zero respectively.
-- The differnce in the ϕ 's ($\Delta\phi$) is calculated.

To find ' h ' i.e. the angular distance from the central scan line :

From the measured $\Delta\phi$, h is evaluated.

$h = f(\Delta\phi) = b\Delta\phi + d\Delta\phi^3 + f\Delta\phi^5$

The coefficients b, d and f are as listed below :

Final set of parameters	Asymptotic Standard Error	
================	===================	
b = -2.76664	+/- 0.004434	(0.162%)
d = 0.00102435	+/- 1.864e-05	(1.819%)
f = -4.34676e-07	+/- 1.655e-08	(3.807%)

To calculate θy_1 and θy_2 :-

Form the measured $\Delta\,\phi$, θy 's are evaluated :

$\theta y_1 = \theta y_2 = \theta y$

$\theta y = f(\Delta\,\phi) = \quad b\Delta\phi + d\Delta\,\phi^3 + f\Delta\phi^5$

In this case, the values of b, d and f are as follows :

Final set of parameters	Asymptotic Standard Error	
================	===================	
b = 2.38264	+/- 0.004661	(0.1956%)
d = -0.0010726	+/- 1.959e-05	(1.827%)
f = 3.99619e-07	+/- 1.74e-08	(4.354%)

In both the fits above the angles h, $\Delta\phi$ and θy are in degrees.