Bull. Astr. Soc. India (2003) **31**, 491–492

Image Reconstruction for a Continuously Rotating Coded Mask Camera

B.T. Ravi Shankar*, Dipankar Bhattacharya
Raman Research Institute, Bangalore 560 080

Abstract. We discuss a method for reconstructing the image for Scanning Sky Monitor which is a continuously rotating X-ray coded mask camera aboard the Indian astronomical satellite, ASTROSAT.

Keywords : X-ray astronomy – all-sky monitor – coded mask imaging

1. Introduction

Scanning Sky Monitor (SSM) assembly aboard ASTROSAT plans to use coded mask imaging technique for source location (Seetha et al 2002). We have earlier reported imaging techniques for SSM in stop-and-stare mode of operation (Bhattacharya and Ravi Shankar 2002). Here we report an imaging technique for SSM cameras in continuous rotation, which makes shadow accumulation difficult.

2. The Technique

Apart from the position information, we now need every event to be time tagged. We select a section of data containing recorded photon strike positions corresponding to a duration of full traverse of a source through the camera field of view. Each recorded photon strike position is then *derotated* to a new position on a virtual detector plane, corresponding to where it would have struck if it came from a source at normal incidence midway through the exposure. This virtual detector plane is 3 times as wide as the real detector and is assumed to be made of elements each of width equal to that of a mask element. Since there are 63 mask elements in a mask plate, there will be 189 elements in the virtual detector. There is also an increase in the extent of the sky imaged over the nominal field of view as the camera scans through the sky during an exposure. The resolution element in the sky along the coding direction corresponds to the shift of the shadow on the virtual detector by one detector element. The sky viewed during the chosen exposure interval corresponds to 251 distinct such resolution elements in the coding direction. Sources at different angles in the non-coded direction cast shadows that have different combinations of

---

*e-mail: ravibt@rri.res.in

wires and mask patterns. Since there are six distinct mask patterns and eight different wires, 55 distinct such combinations can be recognised in the non-coded direction within the field of view. The extended virtual detector plane with 189 detector elements and the sky plane with 251 distinct sky elements along the coding direction and 55 sky elements across, are modelled. For a source at any sky element, the shadow of a specific area of the mask plate will fall on an unique location on the virtual detector plane after derotation. Using this information, we generate the expected shadow patterns (point spread functions) for sources in each of the $nsky = (55 \times 251)$ sky elements. The derotated binned photon counts on each of the eight wires are unwrapped to form a single array of $ndet = (8 \times 189)$ detector elements. The Richardson-Lucy deconvolution technique (Lucy 1974) is employed on this unwrapped detector bin counts and the shadow patterns, which yields the final image.

3. Richardson-Lucy Algorithm

The Richardson-Lucy algorithm, normally used with confined point spread functions, is modified slightly for use with shadow patterns. Each 55 × 251 shadow patterns are area-normalised to unity. The area-normalised initial guess of the source distribution S_i ($\forall\, 1 \leq i \leq nsky$) in the sky is chosen to be flat across all the pixels in the sky.

The algorithm proceeds in the following three steps:

(a). The photon count distribution is predicted using the following relation:

$$P_j = \sum_{i=1}^{nsky} R_{ij} \times S_i \qquad \forall\, 1 \leq j \leq ndet$$

where S_i is the source distribution in the sky and R_{ij} are the shadow patterns.

(b). The predicted values of the photon counts are used to obtain the correction factors C_i for every sky element using the following relation:

$$C_i = \sum_{j=1}^{ndet} \frac{R_{ij} \times D_j}{P_j} \qquad \forall\, 1 \leq i \leq nsky$$

where D_j are the derotated binned photon counts.

(c). The values of the source distribution S_i are corrected using the correction factors C_i as follows:

$$S_i = S_i \times C_i \qquad \forall\, 1 \leq i \leq nsky$$

The corrected source distribution S_i is used to obtain the next set of predictions of photon count distribution P_j'as in (a). The iterative procedure consisting of steps (a), (b) and (c) is carried on till the correction factors C_i converge to unity within a specified tolerance limit. Typically C_i converges after a few hundreds of iterations.

At current level of development we find that this technique is able to recover sources down to ~ 40 mCrab in a 5 minute drift-through of a non-crowded field of view.

References

Seetha, S. et al, 2002, *Bull. Astr. Soc. India*, **30**, 829-831.
Bhattacharya, D., Ravi Shankar, B.T., 2002, *Bull. Astr. Soc. India*, **30**, 833-834.
Lucy, L.B., 1974, *AJ*, **79**, 745.