BLIND DECONVOLUTION OF THE SXT PSF CORE PART

S. Gburek[1], J. Sylwester[1], P.C.H. Martens[2]

[1] *Space Research Centre, Polish Academy of Sciences, Solar Physics Division, Kopernika 11, 51-622 Wroclaw, Poland*
[2] *Montana State University, P.O. Box 173840, Bozeman, MT 59717, USA*

ABSTRACT

We explore a blind iterative deconvolution algorithm for the determination of the core part of the point spread function of the soft X-ray telescope aboard *Yohkoh*. The algorithm has been adapted and modified to deal with the in-flight recorded X-ray images of solar flares. Particular care has been taken to achieve good data selection and initial conditions in order to improve the algorithm performance and convergence. We show an example of a deconvolved point spread function core profile and compare it with ground calibration data.

THE ALGORITHM AND DATA SELECTION

We have adapted the blind iterative deconvolution (BID) algorithm (Ayers and Dainty, 1988) to deal with data from Soft X-ray Telescope (SXT) aboard the *Yohkoh* satellite. The result obtained in Ayers and Dainty paper on synthetic data showed that the algorithm is capable of giving good restorations for both the deconvolved image and the point spread function (PSF). Our, independent, tests revealed that the performance and speed of the BID algorithm depend on the initial guess for the shape of the PSF and the quality of data. Therefore, we took special care in data selection and processing. We have chosen full resolution SXT images taken in Al12 filter for our first PSF restorations. From analysis of compact flare kernel images we came to the conclusion that a good guess for the PSF can be provided directly from images of X-ray compact structures observed by SXT. Trial deconvolutions showed also that the use of compact sources accelerates the BID code convergence. From compact structures that we had found earlier in a search through the entire mission-long database of SXT full resolution frames (Gburek and Sylwester, 2002), we selected the data for the year 2000, a period relatively short in comparison with the duration of the *Yohkoh* mission, but long enough to ensure good coverage over the entire CCD. For comparison of our PSF BID restorations with SXT ground calibration data (Martens, Acton, and Lemen, 1995) we have chosen the *bx02_apr24* series of microfocus source images taken in Al-K line, which lies near maximum of the SXT effective area curve for the Al12 filter. The deconvolutions of the SXT PSF were performed as follows. First, for a given calibration image, we took a sequence of Al12 compact flare images from the same area on the CCD. Then, the initial guess for the PSF core was made with the steepest descent method; a term by Sylwester and Gburek. In short, this method takes an image sequence, normalizes each image to $[0, 1]$ and co-registers them. Then it searches the entire sequence for the lowest signal at any pixel position.

The minimum values for each pixel are collected in a new array of the original image size from the sequence. The authors have checked that good estimates of PSF core can be obtained by this method. The PSF estimate was then deconvolved from the most compact flare image of the sequence and compared to the chosen calibration beam image. The results are discussed bellow.

RESULTS AND CONCLUDING REMARKS

Tests of BID on real SXT data have revealed expected and desirable features: in the deconvolved image there is an increase in signal range and a separation of nearby sources. The structures in the "clean" images are much sharper. Sharpening is also seen in the restored PSF. No significant deformations of the image and PSF, which may come from noise or method artifacts, were detected during the tests. The deconvolved PSF is still slightly more fuzzy that the calibration beam profile in Al-K line (see Fig. 1). Because the observed solar radiation is not monochromatic, one would expect some broadening of the in-orbit PSF with respect to the on ground calibrated in monochromatic spectral lines. In conclusion, an improvement of the morphological and photometric properties of the SXT images can be obtained with the BID method described above. First results show that blind deconvolution is capable of determining the shape of the SXT PSF core in-orbit. We find close agreement with the ground calibrated PSF.

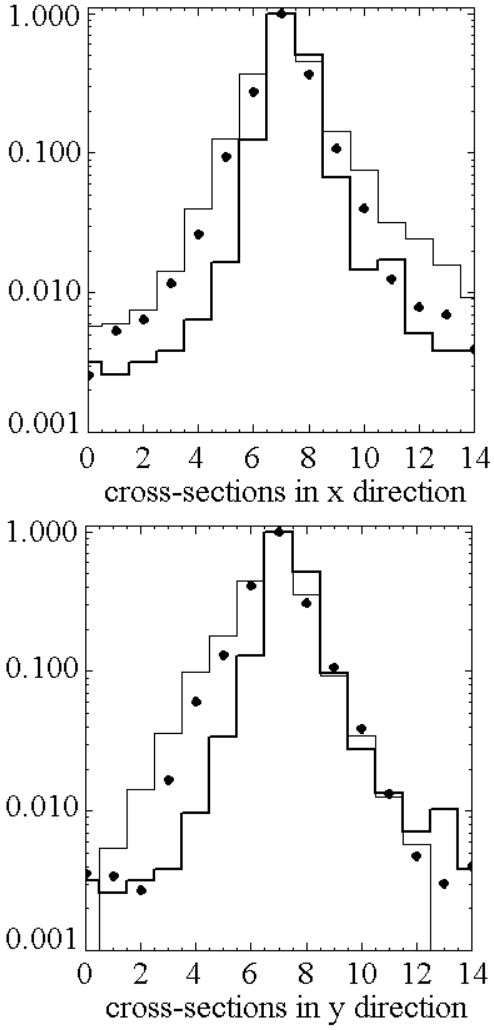

Fig. 1. A result of blind iterative deconvolution for the SXT PSF core and its comparison to ground calibration data is shown in cross-sections in the plots above. Thin solid line - cross-sections of the initial PSF guess constructed by the steepest descent method from a flare image sequence, black dots - cross- sections of PSFs obtained from BID, thick solid line - cross-sections of the SXT PSF from ground calibrations.

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