ADVANCED IMAGING SOLUTIONS OF THE YEAR 2004

Blur Removal from Full-Sky Images of the Universe

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(Nominated by James N. Caron, President, Quarktet)

THE CHALLENGE:

NASA's Wilkinson Microwave Anisotropy Probe measures temperature fluctuations in Big Bang-produced radiation. Analysis of the fluctuations produces a more accurate history of the universe. To increase resolution in the full-sky image, the blur function of the instrument can be identified and removed. The probe takes six months' worth of exposures, a point at a time, as it spins. This produces a wildly complicated blur that is extremely difficult to model and impossible to measure.

THE SOLUTION:

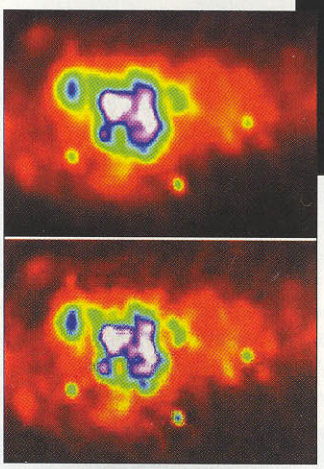
With careful considerations, a blind deconvolution (BD) algorithm can be employed to estimate the blur function and subsequently improve the image. BD estimates the blur function when neither a measured nor modeled blur function is available. Most BD methods are computationally intensive or operate under limited conditions. Quarktet applied the newly-discovered Self-Deconvolving Data Reconstruction Algorithm (SeDDaRA) to the WMAP image with great success. SeDDaRA is unique when compared to current BD algorithms, in that it is non-iterative, producing a result much faster than other methods. It is also not constrained to optical images, allowing application to medical, one-dimensional and space-based applications. The key is to find a reasonable representation of the spatial frequency content of the desired result. Quarktet compared the WMAP image to a collection of fractal images to estimate the blur function and used a pseudo-inverse filter to remove the blur from the image. As shown in these images, both the resolution and contrast are greatly enhanced. The technique has also been applied to personal photography, space-based optical imagery, medical X-rays, ultrasonic waveforms and recorded sound.

THE TOOLS USED:

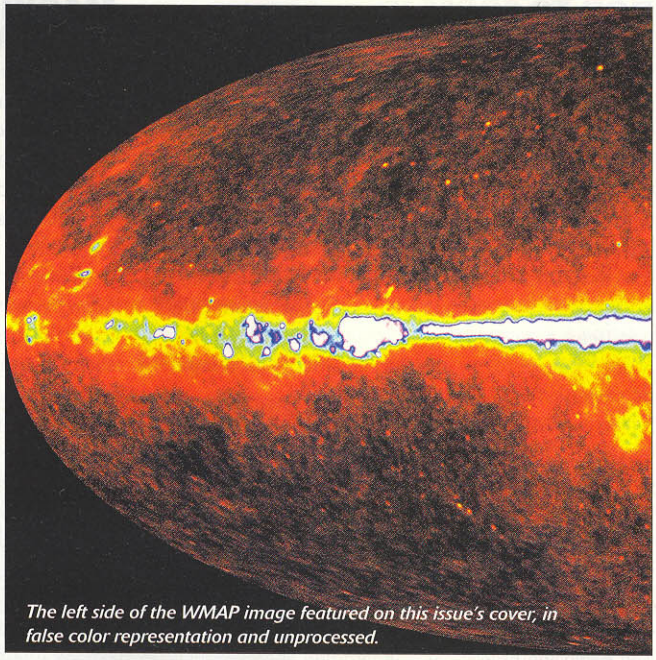
SeDDaRA was developed and utilized with Digital Optics V++ image processing software. The algorithm has also been written into MatLab for both one- and two-dimensional signals. An executable program is currently being developed with Microsoft Visual Basic.

THE DIFFERENCE IT MADE:

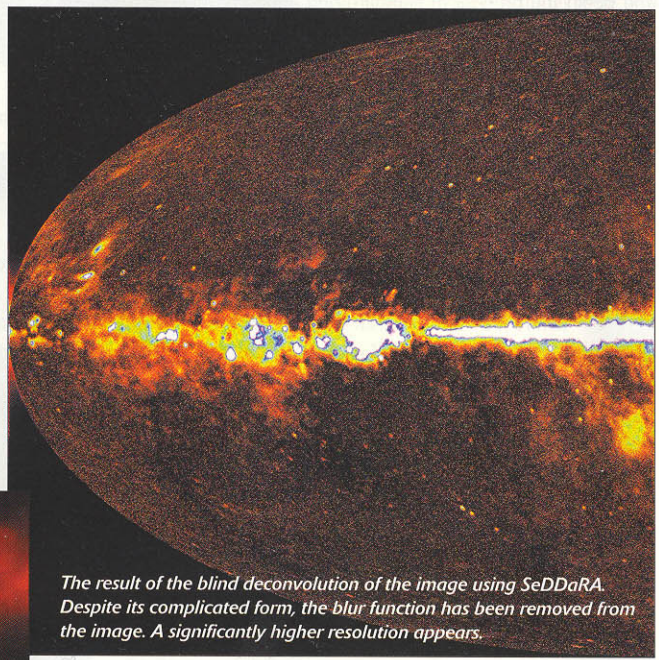
SeDDaRA was able to extract a suitable PSF from the WMAP image despite the complexity of the PSF—and in a few seconds of processing. The PSF was used to remove blur from the image, increasing resolution by almost 10%. With further analysis, parameters such as the age and rate of expansion of the universe will be more accurately calculated. The application of SeDDaRA to WMAP data enables greater resolution to be obtained from the imagery. The costs of image processing are minuscule compared to building a system capable of providing similar resolution.



Top right: A small region of the WMAP image displayed in false color representation. Bottom right: The same region processed using the SeDDaRA technique.



The left side of the WMAP image featured on this issue's cover, in false color representation and unprocessed.



The result of the blind deconvolution of the image using SeDDaRA. Despite its complicated form, the blur function has been removed from the image. A significantly higher resolution appears.

Photos: NASA/WMAP Science Team

REFERENCES:

J.N. Caron, N.M. Namazi and C.J. Rollins, "Non-iterative Blind Data Restoration by use of an Extracted Filter Function," *Applied Optics*, Vol. 41, no. 32, p. 6884, 2002.

J.N. Caron, N.M. Namazi, R.L. Lucke, C.J. Rollins and P.R. Lynn, Jr., "Blind Data Restoration with an eExtracted Filter Function," *Optics Letters* 26(15), p. 1164, 2001.