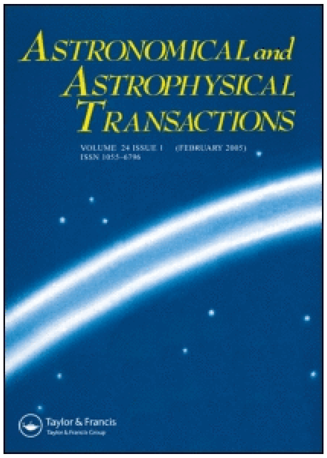

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M. B. Bogdanov [a]
[a] Saratov University, Russia

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A METHOD FOR RESTORATION OF ASTRONOMICAL IMAGES

M. B. BOGDANOV

Saratov University, Russia

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The ill-posed problem of image restoration from incomplete and noisy data, obtained in the coordinate or spatial frequency domain, often arises in optical and radio astronomy. It is known that a linear transformation cannot generate nonzero values at unsampled spatial frequencies. Thus, any successful image restoration techniques requires non-linear methods.

We have developed a method for image restoration by solving the inverse problem for a two-dimensional convolution integral equation based on Tikhonov's regularization theory. The image restoration problem is reduced to the problem of minimization of a certain objective function, the so-called Tikhonov's functional—a linear combination of squared norm of the distance of a calculated blurred image from the observational data in L_2 functional space and squared norm of the restored image in Sobolev's W_2^2 space. The linear regularization method corresponds to the minimization of this functional without any constraints and, therefore, provides only a poor improvement in resolution. Our nonlinear algorithm aims at obtaining a non-negative solution consistent with the observational data. The minimum of the objective function is derived using the projection gradient method. The gradient of the functional is projected on a non-negative function set. This nonlinear constraint allows to take into account *a priori* information regarding the solution and yields better results and superresolution.

The estimation of an image norm in the W_2^2 space requires numerical evaluation of second-order partial derivatives. This operation is difficult enough in the coordinate domain but becomes feasible in the spatial-frequency domain owing to the property of the Fourier transform to reduce differentiation, integration and convolution of functions to algebraic operations. Therefore the calculations of the objective function and its gradient are carried out in the spatial frequency domain using a two-dimensional fast Fourier transform procedure. The projection of the gradient on a non-negative function set is carried out in the coordinate domain using the inverse transform and replacing by zero each negative part of the image.

The developed method was tested with a simulated blurred image and the result was compared with the output of the linear algorithm. The linearly restored image shows large, spurious oscillations which are inevitable with the linear technique, even when the signal-to-noise ratio is very good. The nonlinear method cuts off these oscillations and restores the image with a superresolution.