

Application of regularization algorithms to reconstruction of images with point sources superimposed on a smooth background

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This study is addressed to the problem of reconstruction of the astronomical images with the point sources superimposed on a smooth background. The observed images of point sources can also overlap with each other due to small angular separation between the sources, the finite instrument resolution and atmospheric perturbations. The mathematical model of the image formation can be represented as a convolution equation:

$$(t * z)(x, y) = \iint_B t(x - \xi, y - \eta) z(\xi, \eta) d\xi d\eta = u(x, y), \quad (1)$$

where $(x, y) \in B$ is the area of the image, $z(x, y)$ is the unknown light distribution of the object, $u(x, y)$ represents the observed light distribution of the object. The kernel of the equation (??), $t(x, y)$, is the point spread function (PSF) which describes the response of an imaging system to a point source. This integral equation with error-contaminated right side belongs to the class of ‘ill-posed’ inverse problems. To solve the problem we use Tikhonov regularization algorithm (see [1]).

For extracting the valuable scientific information from the composite image, brightness distribution and astrometry of all its components, the image itself should be decomposed into two parts – the sum of the point sources and smooth background. In our work we represent the point sources by delta functions and use assumption about the closeness of the smooth background to some analytical model (see [3]).

The PSF is assumed to be known and usually constructed from the isolated point sources (stars). However, the shape of the PSF can be very complicated. This includes the signal recording process, the stability of the guiding system and the effects of atmospheric turbulence on the signal. Thus, the errors in the determination of the PSF lead to the errors in the reconstruction of the observed images. In this case the PSF has to be also estimated. In our work, to recover the model of the PSF we also apply the regularization algorithm. This procedure allows to get PSF which is a good representation of the real light distribution of the point source with the minimal losses of the summarised intensity and smooth enough to obtain stable results when adopting this PSF for the image reconstruction of the complex objects.

We investigate the applicability of the developed method to the reconstruction of the images of gravitational lenses observed as a stellar sources superimposed on a diffuse brightness distribution of the background galaxy (see [4]).

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