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Method of Image Denoising in Generalized Phase Space with Improved Indicator of Spatial Resolution

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Abstract—The paper proposes a nonlocal method of additive noise suppression in digital image based on presenting the image in matrix phase space and using nonconventional methods of multivariate statistical analysis, namely, the surrogate data technology that makes it possible to generate a pseudo-ensemble of surrogate images with their subsequent averaging using a single snapshot. This approach is based on properties of the coherent accumulation of signal component of the observation and noncoherent accumulation of its noise component as the size of observation ensemble increases that allows us to partially solve the contradiction between the denoising level and the distortion or loss of small-sized details of image, i.e. reduction of spatial resolution. The simulation modeling of the proposed method of generalized SDT-filtering of noise was conducted using the application software package of MathCad and Matlab. A comparative analysis of the spatial resolution of the proposed and several known methods of denoising has been carried out using the resolution–measurement criterion and the modified Rayleigh criterion. As is shown, the proposed method demonstrates a better spatial resolution as compared to the most common methods of denoising that is confirmed by the results of simulation modeling.

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INTRODUCTION

Denoising (noise filtering) is one of the classical problems of image processing. The efficiency of its solution depends on the selected method of denoising. It is stipulated by the level of residual noise, the degree of small detail smoothing, and the presence of image artefacts. The main purpose of any method is to reduce the noise level in images and at the same time to preserve small details of image.

This problem for the original of digital image distorted by additive noise can be solved by using two approaches. The implementation of the first approach involves the processing of image pixels from a small neighborhood of the pixel subject to correction (local processing). Such processing includes the Gaussian smoothing, anisotropic filtering, Wiener filtering, the threshold wavelet processing, etc. The second approach is based on nonlocal weighted averaging (NLM (non-local means) algorithm) [1, 2] of pixels belonging to different image sections similar to the pixel neighborhood, in which noise is eliminated.

Both approaches (the first to a greater degree) lead simultaneously to the reduction of noise level in image and the smearing (smoothing) of its details and consequently to the degradation of their spatial resolution. If the smoothing can be acceptable for images, where primarily the uniform fragments (water, sky, etc.) are present, however the small details of image (foliage in landscapes, houses, transport vehicles, etc.) can suffer even in the case of cautious attempts of denoising.

Contradiction between the denoising degree and the distortion of image details can be solved by using an approach alternative to the widespread denoising methods that is based on the averaging of several expositions of static image [3, 4]. The averaging is capable of denoising without degrading the detail, because it increases the signal-to-noise ratio (SNR) of analyzed image.

Image averaging is often used in high-class astrophotography. This natural approach towards image denoising is based on properties of statistical characteristics of an ensemble of realizations of random quantities (expositions) to demonstrate the asymptotic efficiency with an increase of the number of elements in ensemble. However, in practice, for example, in the case of aerial reconnaissance or aerial photography, it

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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