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Method of Image Filtering Using Singular Decomposition and the Surrogate Data Technology

P. Yu. Kostenko*, V. V. Slobodyanuk, and O. V. Plahotenko**
Kharkiv Air Force University, Kharkiv, Ukraine
**ORCID: 0000-0002-3382-0684*
***e-mail: sloval@i.ua*

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Abstract—A method for nonlinear filtering of additive noise on digital image has been proposed. This method is based on presenting the image by its matrix singular decomposition and applying the surrogate data technology to components of the image. The proposed method ensures a superior resolution as compared to most common methods of window filtering that is corroborated by the results of simulation modeling.

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INTRODUCTION

Modern computing complexes are used for retrieving useful information from images in radar systems of remote probing, extremal correlation radionavigation, medical diagnostics, biological studies and in the defense sector; however, the last word generally belongs to man. The efficiency of making correct decisions by operator-decipherer depends on the quality of information: the higher is the quality of provided information, the better is the efficiency of decision-making. By the improvement of quality is meant the execution of a complex of operations that result in obtaining images, which are better suited for retrieval of useful information.

The noises present on the image significantly hamper the reliable recognition of objects and their interpretation. The nature of noise formation is different: it can be an additive noise of the receiving device, the pulse noise of data transmission channel, and multiplicative noise inherent to coherent radar systems of remote probing.

The problem of noise suppression on images is one of the classical problems of image processing. The suppression of noises on images in modern software complexes involves the use of local filtering algorithms, such as linear filtering, median filtering, and Wiener filters. A specific feature of these algorithms is the fact that direct processing of image is performed in the sliding window, the dimensions of which usually do not exceed 11×11 pixels. This allows the processing to be made sufficiently fast and does not require additional information about the parameters of noise and useful signal. In addition, the practice of image processing involves the use of methods based on their wavelet transformation and presenting the images by using their main components (MC), and also adaptive algorithms and their different modifications: Lee filter, Sigma filter, Frost filter, etc. [1–3].

Many algorithms for noise suppression lead to degradation of spatial resolution of image details. The better is the noise smoothing, the stronger is the blurring of image details that characterize their spatial resolution. In some cases, when the image contains sufficiently large homogeneous regions, for example water or sky, noise smoothing can be acceptable, however small details of image (buildings, transport vehicles, etc.) can suffer even at the minimum noise suppression.

This contradiction between the degree of noise suppression and the image distortion that depends on the size of filter “sliding window” (aperture, mask) can be solved to a certain degree by applying the filters with dynamic mask size and with adaptation of the aperture size to the image type. In additive filters large apertures are used in monotonous regions of processed signal (for better noise suppression), while small ones are used near inhomogeneities preserving their features [4]. However, adaptive filtering of images implies the knowledge of noise correlation interval coinciding with the size of “sliding window”. It should be noted that despite the degree of noise filtering increases with the rise of the window size, the spatial resolution of window filtering methods decreases due to a growing role of smoothing effects.

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