Panchromatic image denoising by a log-normal-distribution-based anisotropic diffusion model

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Abstract. An anisotropic diffusion model based on a log-normal distribution of a local gray-level is used to propose a way to denoise the panchromatic images. The implication of the low-edge gradient of the feature space for denoising and smoothing the noisy image is adaptively adjusted by the adaptive threshold parameter in a diffusion coefficient function. Furthermore, to terminate the diffusion process, an entropy-based stopping criterion is implemented. The proposed model is compared with the existing models such as Perona–Malik (PM), adaptive PM, difference eigenvalue PM, modified PM, and Maiseli–Gao. In order to analyze the performance of the models, quantitative metrics such as standard deviation, entropy, and the signal-to-noise ratio of a two-dimensional line profile are used. For further analysis, the results of denoising models are segmented using entropy-based segmentation techniques such as Harvda, Renyi, Kapur, and Yen models. A misclassification error metric is used to evaluate the segmentation results. The metric results show that the proposed model effectively removes the noise and preserves the features of a panchromatic image. [DOI: 10.1117/1.JRS.13.014515]

Keywords: anisotropic diffusion; image denoising; segmentation; log-normal distribution; panchromatic image.

Paper 180525 received Jun. 21, 2018; accepted for publication Jan. 24, 2019; published online Feb. 12, 2019.

1 Introduction

A remote-sensing satellite obtains information about the Earth's surface from a distance. Satellites such as landsat, quickbird, cartosat, ikonos, and worldview record the energy that is emitted and reflected from the Earth's surface. All of these satellites provide an image in two modes: (i) a panchromatic sensor provides images with high spatial resolution and (ii) a multispectral sensor provides images with high spectral and low spatial resolution.[1] These images are captured by different portions of the electromagnetic spectrum and tend to be easily corrupted by the noise.[2] Generally, noise in the remote-sensing image is caused by various factors such as sensor saturation, quantization error, thermal effects, and transmission errors.[3] Various applications such as urban planning, feature extraction, land use land cover, and environmental mapping use remote-sensing images. The presence of noisy signals in a satellite image leads to distortion, which subsequently results in a poor interpretation of information.

In the field of image processing, the primary challenge is to remove the noise and at the same time to preserve the edges and texture information of features. Therefore, various methods, such as partial differential equation (PDE),[4] wavelet thresholding,[5] bilateral filtering,[6] and energy minimization,[7] have been proposed to remove the noise from the image. Recently, the PDE method based on anisotropic diffusion has been proposed and widely used for the removal of noise, while preserving the edge information.[4] The anisotropic diffusion equation was first proposed by Pernoa and Malik[8] and is also well known as the Perona–Malik (PM) model. This model is based on the anisotropic diffusion, which is derived using the heat equation. The heat dissipates according to the PDE and it is expressed as follows:

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1931-3195/2019/$25.00 © 2019 SPIE