A Wavelet-Guided Diffusion Equation Implemented via Residual Physics-Informed CNN for Image Denoising

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Our work focuses on image denoising using PDE-based models. The anisotropic diffusion equation attempts to capture edge information through the image gradient. However, in the presence of noise, the gradient fails to provide accurate edge information. To address this issue, our work aims to enhance the denoising capability of the diffusion-based PDE model by incorporating a wavelet prior, which effectively captures edge information.

In addition, an adaptive thresholding strategy is adopted to operate in a completely unsupervised manner. The PDE models are implemented using the finite difference method. To evaluate the denoising performance, two quantitative measures, namely PSNR and SSIM, are used. Experimental results demonstrate that the proposed strategy is applicable to a broad class of image denoising PDE model and significantly improves the denoising performance of the PDE model.

Apart from this, a physics-informed CNN-based algorithm is proposed to solve the PDE model to address additive Gaussian noise. This computational framework adopts a hybrid strategy, where a convolutional neural network is used for prediction, while finite difference-based filters are used for derivative calculations. During training, these finite difference filters are kept frozen. It is observed that the proposed algorithm further enhances the denoising performance by outperforming the classical finite difference method under the same settings.

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