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Near-field Holographic Image Denoising Using Dilated Convolutional Neural Networks

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Near-field holography imaging plays a crucial role in various scientific and industrial applications, offering detailed insights into nanostructures and surface properties. However, the acquired images often suffer from significant noise, particularly at lower exposure times, which can severely impact their interpretability and analytical accuracy. In this study, we present a novel approach for enhancing the denoising capability of near-field holography images using dilated convolutional deep neural networks (DnCNN). By leveraging the advantages of dilated convolutions, our method aims to preserve crucial spatial details while effectively reducing noise artifacts inherent in near-field holography at the lower exposure times. To ensure the preservation of structural similarity between the denoised and input images, we introduce a custom loss function combining L1-norm and Structural Similarity Index (SSIM). Our approach involves training a deep neural network architecture comprising multiple layers of dilated convolutions to capture both local and global contextual information from the input images. The hierarchical feature extraction facilitated by dilated convolutions enables the network to learn complex patterns associated with noise and anatomical structures, thus enhancing its ability to discriminate between signal and noise components. Experimental results on a diverse dataset of low-dose holography images demonstrate the effectiveness of our proposed method in significantly reducing noise while preserving important image features. This study highlights the potential of dilated convolutional neural networks as a promising tool for denoising near-field holography images, facilitating improved analysis and interpretation in various scientific and industrial domains.

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