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Hybrid Image Denoising Using Wavelet Transform and Deep Learning

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Abstract

In this paper, we propose a hybrid image denoising method that combines wavelet transform and deep learning techniques to effectively remove noise from digital images. The wavelet transform is applied to each color channel of the noisy image, decomposing it into different frequency components. The approximation coefficients are then denoised using a convolutional neural network (CNN), specifically designed for this task. The denoised coefficients are subsequently reconstructed to form the final denoised image. Our experimental results demonstrate that this hybrid approach outperforms traditional denoising methods, achieving superior noise reduction while preserving image details. The proposed method is validated using synthetic noisy images, and the results are visually and quantitatively evaluated to confirm its effectiveness.

Keywords: Convolutional Neural Network, Deep Learning, Hybrid Approach, Image Denoising, Wavelet Transform.

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1. Introduction

Image denoising is a fundamental problem in the field of image processing and computer vision, aiming to remove noise from images while preserving essential details and structures. Noise can arise from various sources, including sensor artifacts, environmental conditions, and transmission errors, significantly degrading the quality of images and impacting subsequent tasks such as image recognition and analysis.

Wavelet Transform has been extensively studied and employed in image denoising due to its ability to provide a multi-resolution representation of images, effectively capturing both frequency and spatial information. (1) demonstrated the efficacy of different wavelet transforms in denoising MRI images, highlighting the advantages of wavelet-based methods in medical imaging applications. Similarly, studies have shown the robustness of wavelet transforms in various denoising contexts, including V-band receiver signals and hyperspectral images (2,3).

On the other hand, Deep Learning, particularly Convolutional Neural Networks (CNNs), has revolutionized the field of image processing with its powerful feature extraction and learning capabilities. CNNs have been successfully applied to image denoising tasks, achieving state-of-the-art performance by learning complex patterns and structures directly from the data. (4) proposed a feature attention mechanism for real image denoising, significantly improving the denoising performance on real-world noisy images. Moreover, the integration of wavelet transforms and CNNs has shown promising results, combining the strengths of both methods to enhance denoising effectiveness (5,6).

Hybrid approaches that leverage both wavelet transforms and deep learning have emerged as a powerful solution for image denoising. These methods aim to harness the multi-resolution analysis capability of wavelets and the feature learning strength of deep learning models. For instance, (7) developed a hybrid denoising algorithm based on

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