Application of diffusion process for speckle noise reduction in medical imaging

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Abstract: This study presents a novel application of diffusion processes for speckle noise reduction in medical imaging. Speckle noise, a granular interference inherent in coherent imaging modalities such as ultrasound and optical coherence tomography, significantly degrades image quality and compromises diagnostic accuracy. Traditional denoising methods often struggle to balance noise suppression with the preservation of critical anatomical details, such as edges and fine textures. Leveraging the mathematical framework of partial differential equations, we propose an adaptive diffusion model that dynamically adjusts the diffusion coefficient based on local image features. This approach effectively attenuates speckle while maintaining structural integrity. The model is implemented and validated on synthetic and real medical images, with performance evaluated using metrics including Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), and visual inspection by clinical experts. Results demonstrate that the proposed method outperforms conventional filters, achieving superior noise reduction and detail preservation. This work offers a robust, computationally efficient solution for enhancing medical image quality, thereby supporting more reliable diagnosis and analysis.

Keywords: Diffusion models, speckle noise, medical image denoising, image enhancement