

## Self-Supervised Ultrasound Image Denoising Using Noise2Void and Noisier2Noise

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Speckle noise in ultrasound imaging degrades image quality, leading to reduced diagnostic accuracy and challenges to automated image analysis. Conventional deep-learning methods are hindered by the scarcity of paired clean-noisy ultrasound data. To address this, we propose a self-supervised deep learning framework that integrates Noise2Void (N2V) pretraining and Noisier2Noise (N2N) finetuning for ultrasound image denoising. Unlike conventional supervised methods that require clean ground truth, N2V enables learning directly from single noisy images by masking random pixels and predicting their intensity based on the surrounding context, effectively exploiting spatial redundancy. Building on this, N2N finetuning leverages pairs of noisy images, where one image is synthetically degraded with additive Gaussian noise, allowing the network to learn robust noise mappings without ever accessing clean data. This two-stage strategy addresses the critical limitation of scarce paired datasets in medical imaging. The framework is evaluated against state-of-the-art methods on the publicly available Breast Ultrasound Images Dataset (BUSI) dataset containing 798 images against state-of-the-art methods, and experimental results demonstrate that MedSegUNet achieves an MSE of 0.0003 and a PSNR of 35.38 dB, enabling substantial speckle suppression while preserving fine anatomical details. Although effective on BUSI, performance may vary with device-specific noise characteristics. The model remains lightweight, making it suitable for deployment on small datasets and real-time clinical applications. This work highlights the potential of combining context-based self-supervision and noise-pair learning for practical ultrasound image enhancement.

**Keywords:** Ultrasound image denoising, Self-supervised learning, Noise2Void, Noisier2Noise, Speckle noise