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**UltraDiffusion: Denoising Diffusion Probabilistic Models for  
Enhancing Ultrasound Imaging Quality and Denoising**

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## ABSTRACT

Ultrasound imaging is one of the most essential diagnostic modalities due to its real-time capability, non-invasiveness, and affordability. However, it often suffers from significant challenges such as speckle noise and acoustic clutter, which obscure vital anatomical structures and complicate clinical interpretation. Basic filtering methods and conventional machine learning approaches frequently prove inadequate in managing these complex, non-linear noise patterns.

This research presents "UltraDiffusion," a novel denoising system powered by Denoising Diffusion Probabilistic Models (DDPMs), a class of generative models that have shown outstanding performance in medical imaging. The system was developed by selectively fine-tuning the UNet component of Stable Diffusion v1.5—originally trained on over 8 billion natural images—using a normalised and speckle noise-augmented version of the Kaggle Ultrasound Nerve Segmentation dataset. The training process was optimized using mixed precision, frozen components, and tested on T4 and RTX 4090 GPUs.

The evaluation was conducted using PSNR, SSIM, and LPIPS to measure both visual quality and perceptual similarity. UltraDiffusion consistently outperformed traditional techniques like Gaussian, Median, and Non-Local Means filters. Despite training on a dataset of only 5,000 samples, the model effectively reconstructed basic structural patterns in ultrasound images. These findings highlight the potential of generative modelling, specifically DDPMs, as a valuable approach in medical imaging, offering a promising foundation for future research in diagnostic enhancement and automated ultrasound interpretation, making them a promising direction for future research and clinical application.

### Subject Descriptions:

- Computing methodologies → Artificial intelligence → Computer vision → Computer vision problems → Reconstruction
- Computing methodologies → Computer graphics → Image manipulation → Image processing

**Keywords:** Ultrasound Imaging, Denoising Diffusion Probabilistic Models, Speckle Noise Reduction, Image Enhancement, Machine Learning, Medical Imaging