TRNS Stochastic Damping

Ultrasound RF Channel Denoising

PICMUS 2016 In-Vivo Carotid Data

1. Objective

This study evaluates a training-free TRNS operator for cleaning ultrasound radio-frequency (RF) channel data. Ultrasound RF channel data carry the raw echo information that is later beamformed into B-mode images. Noise present on individual A-lines propagates into the final image, reducing contrast and obscuring fine anatomic detail. Wavelet soft-thresholding is a common baseline, yet it can also shift or attenuate the primary echo packets. An operator that reduces noise while better preserving echo location and relative amplitude is therefore of practical interest.

2. Dataset

Data were taken from the PICMUS 2016 Plane-wave Imaging Challenge. A single central-channel RF A-line was extracted from an in-vivo longitudinal view of the common carotid artery, acquired with a Verasonics Vantage system and an L11-4v linear array. The recording is publicly available clinical research data.

3. Method

The training-free operator and a standard Daubechies-4 soft-thresholding wavelet were applied to the identical normalized A-line. Three metrics were computed:

• RMS reduction — overall noise-cleanup strength

• SNR improvement — signal-to-noise ratio gain in decibels

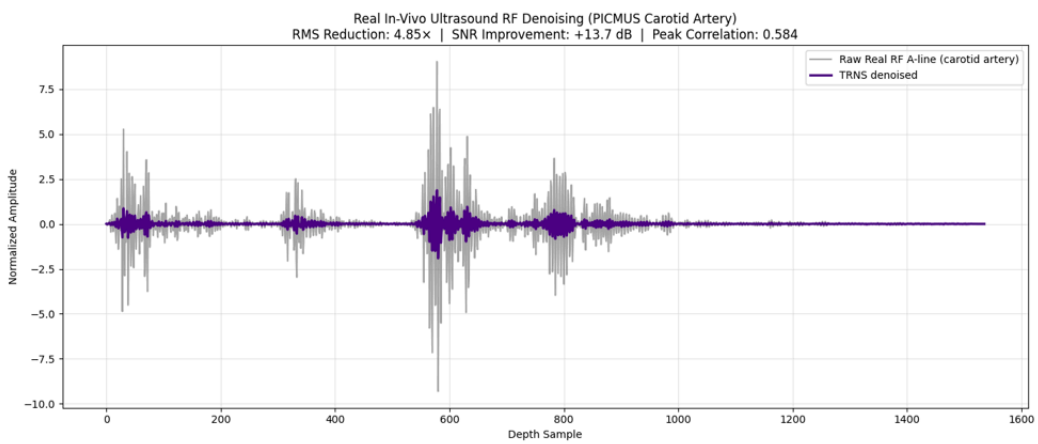
• Peak correlation — fidelity of the locations and relative amplitudes of the prominent echoes

4. Results

Metric	TRNS	Wavelet	Difference
RMS Reduction	**4.85×**	1.17×	+3.68×
SNR Improvement	**+13.7 dB**	+1.4 dB	+12.3 dB
Peak Correlation	**0.584**	0.020	+0.564

Larger noise reduction and markedly better echo-structure preservation than the wavelet baseline.

Figure 1. Real in-vivo ultrasound RF A-line from the PICMUS 2016 carotid dataset. Gray: raw RF channel data. Purple: TRNS-denoised output. The operator suppresses background noise while retaining the positions and relative amplitudes of the primary echo packets.



5. Interpretation

On this real clinical RF trace the operator delivered substantially stronger noise reduction (4.85× RMS, +13.7 dB SNR) while also preserving the locations and relative amplitudes of the main echo packets far more faithfully than the wavelet baseline. The higher peak correlation (0.584 vs 0.020) indicates that the structural information needed for subsequent beamforming survived the cleaning step more intact.

Because the method is training-free and operates on individual A-lines, it can serve as a lightweight front-end stage before beamforming on research or edge ultrasound platforms without requiring dataset-specific model training.

6. Positioning

Training-free RF-channel regularizer that can serve as a front-end stage before beamforming on research or edge ultrasound platforms where both noise suppression and echo-structure fidelity are required.

7. Limitations

Results are reported on a single central-channel A-line from one PICMUS acquisition. Performance may vary with depth, acquisition settings, transducer, or different anatomical targets. Peak correlation is a useful indicator of structure preservation but does not replace comprehensive image-quality assessment after full beamforming (contrast, resolution, or speckle statistics).

8. Conclusion

On real in-vivo PICMUS carotid RF data, TRNS achieved strong noise reduction while preserving echo structure substantially better than a standard wavelet baseline. These properties support its use as a practical, training-free front-end regularizer for ultrasound RF channel data.

References

Liebgott, H., Rodriguez-Molares, A., Jensen, J. A., & Bernard, O. (2016). Plane-wave imaging challenge in medical ultrasound. 2016 IEEE International Ultrasonics Symposium (IUS). https://doi.org/10.1109/ULTSYM.2016.7728908

PICMUS Challenge Repository: https://www.creatis.insa-lyon.fr/Challenge/IEEE_IUS_2016/