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Attention - Enhanced Denosing diffusion probabilistic modles for underwater acoustic signals

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Abstract

The underwater acoustic signal processing gather difficulties due to the maze-like noise environments to marked by the ambient to interference from ocean currents, sea traffics,and biological source, coupled with pronounced signal degradation resulting from the multipath propagation and frequency-dependent reduction. The denoising techniques to conventional on oversimplified noise models and necessitate considerable human parameter adjustment, their diminishes in dynamic marine settings . to study introduces an innovative and frame work that integrates denoising diffusion probabilistic models(DDPM) with self-attention processes .the methods used for a (1-D U-net)architecture that works on a row time-domin waveform sampled at 16 kHz and 200 step diffusion process used with linear noise scheduling.this type attention model uses six transformer-style blocks with 4-head scaled dot-product in attention placed included between the convolutional encoder and decoder stages. The advanced hybrid model to places attention at deeper U-Net stages and to capture the bottleneck long-range of dependencies alongside in diffusion-based noise removal.this type of Experiments on synthetic underwater signals (multi-tone sinusoids at 50–800 Hz with coloured noise at 5 dB SNR) the each model is showed has distinct strength. The models of attention only can achieved the best in SNR of 8.90 dB through a deterministic inference.the DDPM with attention model to achieved the best spectral reconstruction, with matching the clean reference exactly a spectral flatness of 0.000, the both individual models on frequency-domain fidelity.the only model of DDPM provided the effective noise reduction but the broadband artefact introduced from its stochastic sampling. These diffusion and attention offer complementary strengths are show in result , and the combination of them produces the most faithful spectral recovery, to the framework a practical candidate for making the application in autonomous underwater vehicles, sonar systems, and marine monitoring.

Keywords: The Underwater Acoustic Signal Processing and Denoising Diffusion Probabilistic Models with Attention Mechanism, Deep Learning, Signal Enhancement, Sonar Systems, Marine Acoustics, Neural Audio Processing.