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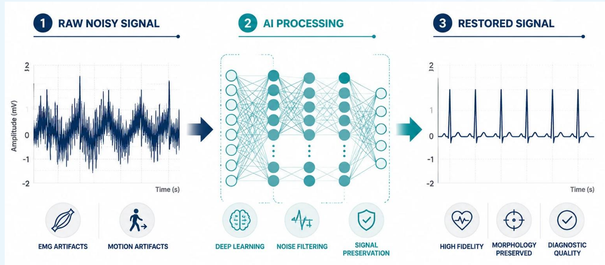


Novel Artifact Removal and Noise Reduction Techniques for Vital Signals in Clinical Environments: A Systematic Review

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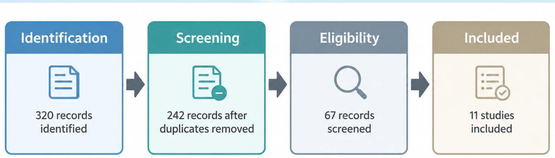


Backgrounds

- **The Telecardiology Paradigm:** Wearable ECG devices enable continuous, real-time cardiac monitoring outside clinical settings, critical for early cardiovascular disease (CVD) management.
- **The Noise Challenge:** Ambulatory recordings are severely degraded by baseline wander (BW), power-line interference (PLI), electromyographic (EMG) noise, and motion artifacts (MA).
- **Diagnostic Risks:** Unmitigated artifacts distort ST-segments and QRS morphology, provoking false alarms, alarm fatigue, and automated misdiagnoses.
- **Algorithmic Transition:** While conventional filters manage stationary noise, deep learning (CNNs, GANs, RNNs) excels at non-linear, dynamic motion artifact removal.
- **Study Objective:** Systematically evaluate and benchmark traditional versus AI-driven ECG denoising techniques regarding signal fidelity (ΔSNR), edge deployability, and clinical interpretability.

Methods

Following the standard **PRISMA 2020** protocol, an initial search of reputable scientific databases yielded 320 records. After removing duplicates and screening titles and abstracts based on inclusion criteria specifically the presence of quantitative data such as SNR and physiological validation a final selection of **11 studies** was identified for inclusion in the review.

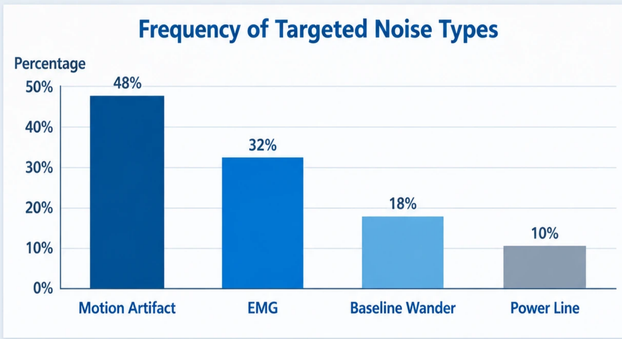


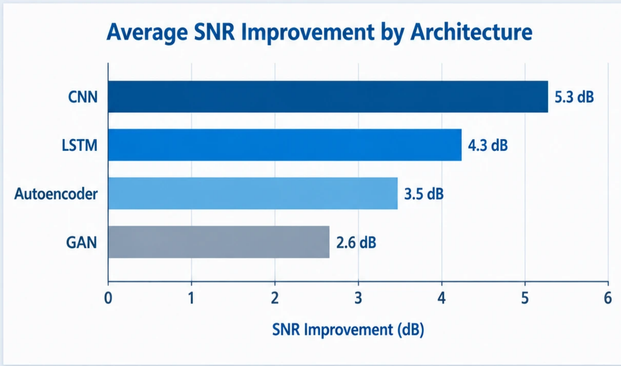
Findings

Paradigm	Target Noise	Representative Methods	Strengths	Limitations
Adaptive & EMD	BW, PLI, Mild MA	VSS-LMS, EEMD	Good QRS preservation	Mode mixing, iterative latency
Wavelet (DWT)	EMG, High-Freq	Thresholded DWT	Fast, real-time viable	Spectral overlap in severe MA
Deep Learning	Severe MA, Mixed	1D-CNN, LSTM, GAN	State-of-the-art SNR & fidelity	High compute cost, paired data needs

4-Pillar Strategic Framework for Clinical Deployment

Pillar	Strategic Focus	Rationale for Clinical Deployment
Algorithmic Synergy	Hybrid Pipeline (Filter + DL)	Combines lightweight classical filtering for stationary noise with DL for complex artifacts.
Computational Feasibility	Edge-Device Optimization	Matches model complexity to power/latency limits of wearable telecardiology devices.
Clinical Interpretability	Morphology Preservation	Ensures denoising preserves QRS/ST-segment integrity to prevent diagnostic errors.
Dataset Generalizability	Multi-Center Validation	Moves beyond benchmark databases (MIT-BIH) to ensure robustness in real-world patient dynamics.





Conclusion

1. Paradigm Shift

Deep Learning outperforms traditional filters for non-linear artifacts like MA and EMG.

2. The Core Trade-off

GANs & CNNs offer peak fidelity, but edge deployment demands lightweight models.

3. Clinical Translation

Future relies on hybrid filtering pipelines with strict ECG morphology preservation.

References

1. Konstantinou GN, Anderson WC 3rd, Bagkis E, Brown Z, Karatzas K, Kassandros T, et al. AI-driven wearable and connected technology for allergy: real-time monitoring and predictive management for personalized care. J Allergy Clin Immunol Pract. 2025 Oct 4..
2. Boulanger P. From motion artifacts to clinical insight: multi-modal deep learning for robust arrhythmia screening in ambulatory ECG monitoring. Sensors (Basel). 2026 Feb 10;26(4):1135.
3. Hizem M, Bousbia L, Ben Dhiab Y, Aoueileyine MO, Bouallegue R. Reliable ECG anomaly detection on edge devices for Internet of Medical Things applications. Sensors (Basel). 2025 Apr 15;25(8):2496.