

Optimizing the ECG Data Lifecycle for High-Fidelity Clinical Decision Support

Madalina Elena DATCU*, Adrian DOLOCA, Cristina-Gena DASCALU, Vasile Lucian BOICULESE, Mihaela MOSCALU

Preventive Medicine and Interdisciplinarity Department, Faculty of Medicine, Grigore T. Popa University of Medicine and Pharmacy Iași

E-mails: madalina.dtc@gmail.com; adrian.doloca@umfiasi.ro; cdascalu_info@yahoo.com; lboiculesc@gmail.com; moscalu.mihaela@gmail.com

* Author to whom correspondence should be addressed;

Abstract

The integrity of the medical data lifecycle is fundamentally contingent upon the signal fidelity established during the initial acquisition phase. In wearable cardiology, the transition from controlled clinical environments to ambulatory monitoring introduces significant signal degradation primarily caused by motion artifacts and skin-electrode interface instability. This research addresses the fundamental technical constraint of transduction noise, proposing a framework to ensure data integrity from initial collection to clinical decision support. The study proposes a synergistic methodology to evaluate the integration of advanced biosensing materials—including dry, flexible, and textile-based electrodes—with adaptive signal processing architectures. The research focuses on how electrode morphology influences biopotential capture, with a priority on attenuating impedance variability. Furthermore, the framework incorporates real-time filtering algorithms specifically designed to suppress non-stationary noise, ensuring that extracted features accurately represent underlying cardiac physiology. Preliminary conceptual assessments and initial tests indicate that bio-adaptive sensing interfaces, when combined with context-aware processing, can significantly enhance the Signal-to-Noise Ratio (SNR). By targeting baseline wander and electromyographic interference at the hardware-software interface, high-fidelity extraction of pathological markers is achieved. These initial findings suggest that optimizing the acquisition layer leads directly to improved sensitivity in automated diagnostic tools. Refining the front-end of the medical data lifecycle is essential for the scalability of digital health solutions. This study establishes a robust foundation for next-generation ECG monitoring systems. By prioritizing high-fidelity acquisition, the proposed framework enables more precise, real-time clinical decision-making within a digital-first healthcare infrastructure.

Keywords: ECG signal; Medical data lifecycle; Wearable devices; Signal processing.

