Soft QRS Mask Fusion for Morphology Preserving ECG Denoising Under Real World EMG Noise

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Introduction: The electrocardiograms (ECGs) recordings can be contaminated by various noise, and particularly the Electromyographic (EMG) noise, which still challenges removal due to the spectrum overlaps with the ECG morphology, leading to clinical diagnosis issues. Strong smoothing approaches help reduce noise but may lead to distortion of important features, highlighting the need for morphology-preserving denoising techniques. **Methodology**: We propose a hybrid morphology-preserving ECG denoising framework based on parallel processing and soft fusion. The first branch targets low-frequency components to preserve P/T and ST segment, while the second branch tracks high-frequency components to preserve sharp QRS complexes. A third QRS activity branch is used exclusively to effectively localize R peaks and construct a smoothly varying fusion weight through temporal smoothing, enabling gradual transitions between branches and avoiding switching artifacts. The method is evaluated on the SimEMG database, which provides EMG-contaminated ECG recordings. **Results**: Mean SNR improvement (SNRimp) was 8.27, 7.72, 5.32, 3.41, and 2.20 dB for input SNR (SNRinp) <4, 4-8, 8-12, 12-16, 16-20 dB, respectively. Average correlation increased up to 0.995 with PRD values decreased to reach 10.25%. **Conclusion**: EMG noise can be effectively suppressed by using soft mask fusion while preserving ECG morphology without needing reference data, reflecting a robust performance to be a strong solution for real-world noise removal.

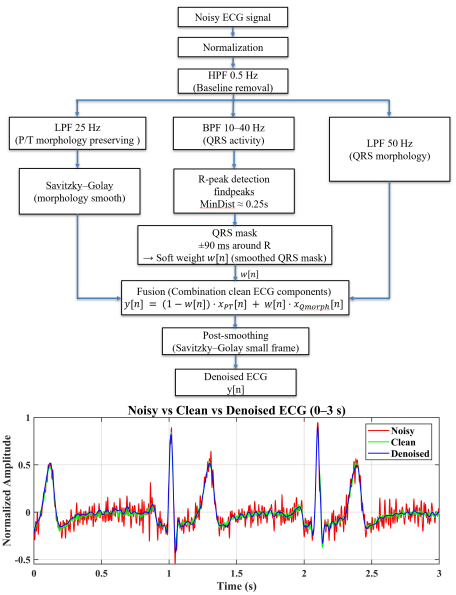

Fig. 1. Flowchart of the Proposed ECG Denoising Method.