An Efficient Algorithm Based on Wavelet Transform to Reduce Powerline Noise from Electrocardiograms

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Background and Aim. The electrocardiogram (ECG) is the most widely used signal in the assessment of cardiac pathologies. However, this recording is often disturbed by nuisance signals, including powerline interference (PLI). In order to avoid misdiagnosis, PLI removal from the ECG is hence mandatory. A wide variety of methods have been proposed for this purpose. However, common notch filtering approaches may alter notably the morphology of the ECG. Although more advanced algorithms can partially avoid this problem, they are computationally expensive. Hence, this work introduces a simple and efficient algorithm to suppress PLI from the ECG.

Methods. To validate the method, fifty 10-min length clean ECG segments obtained from the MIT-BIH Normal Sinus Rhythm database were contaminated with a sinusoidal signal of 50 Hz and variable harmonic content to obtain signal-to-interference ratios (SIR) of 15, 10, 5, 0, -5 and -10 dB. Then, the noisy ECGs were decomposed into 4 Wavelet levels through a sixth-order Daubechies function. Wavelet coefficients were thresholded to remove PLI from TQ intervals and to preserve QRST complexes. The denoised ECG signal was finally reconstructed by computing the inverse Wavelet transform (WT). For comparison, a common adaptive notch filtering was also considered.

Results. Original and denoised ECGs were compared through a signed correlation index. With respect to adaptive filtering, the proposed method reported improvements between 16–74%. Note that WT-based denoising presented a stable behavior regardless of the noise level, whereas the adaptive filtering was specially sensitive to large interferences (see the table below).

Conclusions. An efficient and simple algorithm to suppress high levels of PLI from the ECG has been introduced. The method is featured by an enhanced trade-off between noise reduction and signal morphology preservation.

	SIR (dB)					
Method	**15**	**10**	**5**	**0**	**−5**	**−10**
WT-based	95.7±3.5%	95.1±3.9%	94.7±4.2%	94.5±4.4%	94.4±4.4%	94.4±4.4%
Adap. filt.	79.1±6.3%	77.1±6.0%	70.1±4.9%	54.1±2.6%	34.8±0.8%	20.2±0.3%