Application of Joint Notch Filtering and Wavelet Transform for Enhanced Powerline Interference Removal in Atrial Fibrillation Electrograms

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Background and Aim. The analysis of electrograms (EGMs) constitutes the most common way to gain new insights about the mechanisms triggering atrial fibrillation (AF). However, these recordings are highly contaminated by powerline interference (PLI) due to the large amount of electrical devices operating simultaneously in the EP lab. To remove this perturbation, conventional notch filtering is widely used. However, this method adds artificial fractionation to the EGMs, thus concealing their accurate interpretation. Hence, the development of novel algorithms for PLI suppression in EGMs is still an unresolved challenge. This work introduces the joint application of common notch filtering and Wavelet denoising for enhanced PLI removal in AF EGMs.

Methods. According to a previously published model, 100 clean unipolar EGM signals were synthesized. Next, a sinusoidal signal of 50 Hz and variable harmonic content was added to the EGMs to obtain signal-to-interference ratios (SIR) of 25, 20, 15, 10 and 5 dB. These noisy EGMs were notch filtered with a bandwidth of 2 Hz. Although the obtained noise was disturbed by EGM residua, PLI power was precisely estimated from its spectral distribution. This information was then used to threshold Wavelet coefficients in the first five time scales obtained with a 2nd-order Coiflet function. The denoised EGM was finally reconstructed by using the inverse Wavelet transform (WT).

Results and Conclusions. Original and denoised EGMs were compared in terms of a signed correlation index (SCI), computed both in time and frequency domains. Compared with the single use of notch filtering, improvements between 4% and 15% were reached with Wavelet denoising in both domains (see the table below). Consequently, the combination of common notch filtering and WT-based denoising has been able to reduce efficiently high levels of PLI and preserve the original morphology of AF EGMs.

		SIR (dB)				
Method	**SCI (%)**	**25**	**20**	**15**	**10**	**5**
WT-based	Time	94.1 ± 1.6	93.6 ± 1.6	92.4 ± 1.6	89.6 ± 1.7	85.9 ± 2.5
	Frequency	99.5 ± 0.3	99.4 ±0.3	99.3 ± 0.4	99.1 ± 0.4	98.5 ± 0.5
Notch filtering	Time	79.0 ± 4.1	78.9 ± 4.1	78.9 ± 4.1	78.8 ± 4.0	78.3 ±4.1
	Frequency	96.4 ± 0.6	96.4 ± 0.6	96.4 ± 0.6	96.3 ± 0.6	96.3 ± 0.6