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An Efficient Power-Line Interference Removal System for Electrocardiograms

Ajward A.M.

Department of Engineering Technology, University of Ruhuna, Kamburupitiya, Sri Lanka

Even though many adaptive notch filter based literature techniques for removing Power-Line Interference (PLI) noise with harmonics are available, these known techniques are often inefficient for Electrocardiogram (ECG) signal PLI noise removal. Inefficiencies occur mainly due to a number of facts: (1) the adaptive notch filters that create distortions in the ECGs, (2) the need of significantly larger filter lengths to achieve the required narrow bandwidths, (3) the requirement of complicated multiple-notch filter designs, and (4) the inconsistencies in filtering efficiencies. Thus to remove the PLI noise efficiently without corrupting the ECG signal's important characteristics, a novel Adaptive Quadrature Notch Filter (AQNF) based technique is proposed and developed. In the proposed AQNF, the quadrature signal is generated by convolving the input signals with new response functions. The performance of the proposed system was tested using ECG records from the MIT-BIH arrhythmia database. The clean records were contaminated by PLI noise with harmonics and then filtered using the new AQNF technique. The signal to noise ratios (SNRs) and heartbeat rates of the filtered ECG output signals were estimated with different input SNRs for the proposed and typical techniques. The AQNF that has a simpler but consistently efficient multi-notch filter design, achieved a narrow bandwidth using a short filter length while not distorting the ECG signal. Compared to the typical technique, the proposed AQNF implementation shows significant improvements in the filtered ECG SNRs and the accuracy of the estimated heartbeat rates. The proposed technique can be used for efficient and robust ECG signal conditioning and subsequent analysis.

Keywords: *Electrocardiogram, Power-line Noise, Adaptive Quadrature-Notch-filter*

*Corresponding author: ajwardma@gmail.com